TECHNICAL EVALUATION REPORT

IMPLEMENTATION GUIDANCE FOR NEW AND CORRECTIVE EQUIPMENT ENVIRONMENTAL QUALIFICATION

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FOREWORD

This Technical Evaluation Report was prepared by Franklin Research Center under a contract with the U.S. Nuclear Regulatory Commission (Office of Nuclear Reactor Regulation, Division of Operating Reactors) for technical assistance in support of NRC operating reactor licensing actions. This Implementation Guide was prepared in accordance with criteria established by the NRC.

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1. PURPOSE

The purposes of this guide are threefold. The first purpose is to *provide guidance for the development of a complete qualification program or* for the first-time qualification of a single device. This guidance is detailed in Section 3.

The second purpose, contained in Section 4, is to provide guidance for corrective action for deficiencies found in existing qualification documentation. The guidance provided was developed with cost effectiveness and practicality as considerations. It is not the intent of this document to impart new requirements or to limit the options for resolution of qualification issues; the intent is to provide possible solutions to qualification problems as determined by the reviewers of documentation for equipment in operating plants and to facilitate fulfillment of existing requirements. Other methods of resolution may be available and valid.

The third purpose is to discuss qualification issues for specific devices that require requalification efforts. These discussions are contained in Section 5, which is divided into two subsections: one concerning equipment requiring major requalification work, and the other concerning problems of a more easily corrected nature.

2. BACKGROUND

2.1 BACKGROUND

On May 23, 1980, the NRC issued Memorandum and Order CLI-80-21, specifying that licensees and applicants must meet the requirements set forth in the DOR Guidelines and NUREG-0588.

In mid-1981, the NRC issued Safety Evaluation Reports (SERs) on environmental qualification of safety-related electrical equipment to licensees of all operating plants. Where additional qualification information was required, the licensees were directed to respond to the NRC within 90 days of receipt of the SER.

In October 1981, the NRC authorized Franklin Research Center (FRC) to evaluate the licensees' resolutions of outstanding issues on equipment environmental qualification (EEQ) as discussed in the NRC SERs. The assignment was to review the qualification documentation in accordance with NRC criteria and to present the results in the form of a Technical Evaluation Report (TER) for each of the 71 operating plants.

As part of the review assignment, this implementation guide has been prepared as an aid in fulfilling NRC qualification requirements. This guide also provides clarification of basic qualification deficiencies determined from the technical evaluation of the licensees' resolutions of outstanding NRC SER items. An effort has been made to furnish enough information on pertinent technical issues to allow correction of deficiencies found during the review of the qualification documentation for the operating plants.

2.2 SCOPE

The scope of this implementation guide and of the evaluation of operating plant qualification by FRC was limited to safety-related electrical equipment located in harsh environments. While many of the techniques described in this document may be applied to mild environment qualification, this document is not intended as a guide to mild environment qualification nor are all of the requirements and methodology described herein applicable to mild environment equipment.

3. DEVELOPMENT OF AN EQUIPMENT ENVIRONMENTAL QUALIFICATION PROGRAM

3.1 OVERALL PROGRAM CONSIDERATIONS

The most common method of environmental qualification of electrical safety-related equipment for nuclear power plants is analysis and testing of individual pieces of equipment rather than complete systems. Therefore, proving that the assembled system is qualified requires a comprehensive program to assure that the components in the systems and their interfaces have been qualified, thereby qualifying the whole system.

To assure adequate environmental qualification of equipment while reducing program costs to the extent possible, a review of the equipment and systems should be performed to limit the scope of the qualification program and assure that all equipment that should be qualified is included in the qualification program. Time spent in developing clear plant-specific criteria for application of environmental qualification requirements will help assure adequacy of the qualification and will aid continuing qualification efforts during plant modification and maintenance, and spare parts procurement.

To further reduce the impact of qualification while assuring adequacy of the program, the specified normal, abnormal, and accident environments should be reduced to the most benign levels possible that are still conservative. Reduction of the specified normal environmental parameters will reduce aging requirements with the benefits of longer qualified life or higher probability of withstanding postulated accidents.

The operating conditions of the equipment must also be determined. Voltage, frequency, load, operational cycles, and process conditions pertinent to the equipment should be determined before beginning qualification so that all parameters affecting the equipment can be evaluated and simulated.

Before beginning the qualification of a particular device, its safety function must be known to allow determination of the pertinent parameters to be monitored during qualification and to determine acceptance criteria. Complete definition of the safety function is particularly important for

complex devices having subcomponents which may not be required to support the safety function and could be eliminated from qualification by use of a failure modes-and-effects analysis.

During the entire qualification process, it is important to document the assumptions and the considerations underlying the choice of particular options for qualification. This documenting is necessary because use of existing or older qualification reports and documents is often limited by the inability to reconstruct the decisions and events that occurred when the qualification was performed.

The following sections discuss considerations to be included in the qualification process. A review of the considerations with respect to a particular device to be qualified will allow elimination of those that are not applicable. The discussions were made as inclusive as possible to help eliminate problems found in qualification programs which were reviewed.

A complete qualification is generally not performed by one group. Most qualifications involve the manufacturer, vendor, architect-engineer or steam system supplier, and licensee. When generic qualification programs are used, the licensee or his agent must verify the adequacy of the qualification for the specific application. Frequently, this verification process demands that further analysis, evaluation, and/or testing be performed to provide complete qualification of the device.

3.2 ELEMENTS OF A QUALIFICATION PROGRAM

The following subsections provide guidance for a comprehensive qualification program. It is recognized that many of the concerns addressed do not apply to every device to be qualified. This document discusses requirements of the pertinent standards and, to some extent, indicates how requirements can be met. However, the NRC and FRC have agreed that this guide cannot possibly provide guidance for every environmental qualification concern. It is not intended to be a "cookbook" for qualification methodology; the licensees and their agents must determine the appropriate qualifications to be taken for their specific needs.

3.2.1 Defining the Scope of the Program

3.2.1.1 Identification of Safety-Related Systems and Equipment

Defining the scope of the qualification program ensures that required devices are qualified, eliminates needless qualification efforts, and reduces replacement procurement problems. The establishment of clear plant-specific criteria for determining which devices require qualification must be done at the outset of the qualification effort to provide a basis for the program and to allow for easier evaluation of the program during the life of the plant.

The program should also establish criteria for determining whether subcomponents require qualification. The safety function of the subcomponent should not be the sole determinant for requiring or not requiring qualification. Some non-safety-related equipment will require a failure modes-and-effects analysis with regard to surrounding or interconnected safety-related components to determine qualification requirements.

The following section provides guidance on reducing the list of items requiring qualification through evaluation of the function of the device with regard to the environments experienced and the qualification of redundant systems.

3.2.1.2 Systems Considerations

For some equipment items located in harsh environments, detailed consideration of specific safety functions may reveal that the safety function could be achieved without equipment replacement, relocation, or development of additional qualification documentation. These considerations, called systems considerations, take several forms: (1) the safety function can be achieved prior to onset of harsh conditions; (2) the safety function is performed well in advance of the expected onset of equipment failure; (3) environmentally qualified backup equipment that performs the same function is available; or (4) other available backup equipment performs the function and is not exposed to a harsh environment simultaneously with the primary equipment.

The following examples are typical systems considerations which can reduce or eliminate environmental qualification requirements for specific equipment items:

- A containment pressure transmitter is located in a pipe tunnel outside containment. The transmitter is exposed to a harsh environment by a HELB in the pipe tunnel. The transmitter initiates containment isolation upon sensing high containment pressure. This containment isolation signal is not required in the event of a HELB in the pipe tunnel, but is required for a LOCA or HELB inside containment. For a LOCA or HELB inside containment, the transmitter is not exposed to a harsh environment. Environmental qualification of this transmitter for the harsh HELB environment is not required since its safety function is required only when it is not exposed to the harsh environment inside containment. Qualification is required for the lesser environment due to the LOCA.

- Safety-injection accumulator (or core flood tank) pressure transmitters are located inside containment. Plant operators monitor this pressure indication during normal operation to ensure that minimum pressure is maintained so that core flood capability is available during the first few seconds of a major LOCA while the active safety-injection systems are being initiated and are achieving rated capacity. The safety function of this equipment (reactor core cooling) is achieved in the first 10 seconds of the accident and the functioning of the pressure transmitters is not required thereafter because their safety function is performed prior to the start of the LOCA. Subsequent failure of the transmitters does not affect safety-related power supplies and will not cause the operator to be misled.

  Note: This example does not concern an item that functions during the first few minutes of a LOCA. It concerns a system that is required prior to the onset of a LOCA and required during normal operation only.

It is difficult to prescribe specific systems considerations for environmental qualification of equipment subject to harsh environments because each consideration is usually plant-specific. General guidelines have been established for evaluation of systems considerations; however, these guidelines are not all inclusive.

The following are some technically valid systems considerations:

- The equipment does not provide a safety function or mitigate the consequences of a LOCA or HELB, and its failure will not degrade equipment performing these functions.

- o The equipment is not exposed to a harsh environment by the accident it was installed to mitigate. Subsequent failure of the equipment will not have an adverse effect on other safety-related equipment and will not have the effect of misleading an operator.

- o Backup equipment having sufficient redundancy is available which completely performs the safety functions of concern. The backup equipment is environmentally qualified and will perform the function in spite of a postulated single active failure. Subsequent failure of the equipment will not have an adverse effect on other safety-related equipment and will not have the effect of misleading an operator.

- o The equipment's function is completed prior to the onset of the harsh environment. No subsequent functions are necessary. Subsequent failure of the equipment will not have an adverse effect on other safety-related equipment and will not have the effect of misleading an operator.

  Note: Considerations for reducing or eliminating qualification requirements because the safety function is completed prior to the onset of harsh conditions should not ignore environments resulting from small-break LOCA and HELB events. Small breaks with more gradual development of harsh conditions may cause equipment degradation due to the lag in detection of the accident condition and may result in significant localized equipment damage.

In general, the following items are cause for rejection of a systems consideration:

- o The backup equipment is not fully capable of performing the intended safety function.

- o The backup equipment is not environmentally qualified and can be exposed to a harsh environment simultaneously with the primary equipment.

- o The backup equipment is subject to a potentially disabling single active failure.

- o Failure of the primary equipment can affect other safety-related equipment or power supplies.

- o Failure of the primary equipment can result in erroneous indication which could mislead an operator.

- o Functioning of the primary equipment is required throughout the post-accident period.

- o Although backup equipment is available, it is not technically sound to relinquish defense-in-depth for this particular function (single failure criteria not satisfied).
- o The backup equipment is not safety-related.
- o The primary equipment is necessary for the operator to ascertain that an engineering safety feature (ESF) system is performing its intended safety function.
- o The "systems consideration" justification is not based on objective technical evidence.

Sometimes systems considerations can justify reduced environmental requirements for environmental qualification. For example, if a systems consideration concludes that a certain equipment item needs to function for only several hours after the start of a design basis accident, and an integrated radiation dose is the only environmental parameter of concern, then documentation of the limited radiation dose and the validity of the systems consideration may combine to achieve satisfactory qualification for the equipment.

3.3 QUALIFICATION OF A DEVICE

The qualification process should begin with the gathering of the pertinent data concerning function, application, and environments for a device. If certain pieces of data are not available when defining the qualification program, conservative estimates must be used until such data become available through later analysis or actual measurements during operations. The following subsections describe the significant qualification steps. Guidance is given in areas that proved troublesome during past qualification efforts.

3.3.1 Development of the Plan for Qualification

When a device must be qualified, a plan describing the method of qualification should be prepared. This plan should include the safety function of the device; a description of the device; and a description of the environment, power conditions, and operating specification. The plan should then detail the methods to be used, such as testing with supporting analyses, rigorous

analysis supported by testing, or full analysis with a summary of the basic steps to be taken. For devices that have been qualified previously, this plan may be part of the qualification procedure. The plan for qualification provides subsequent reviewers with the logic of the program and will ease their evaluation process.

Section 6.2 of IEEE Std 323-1974, Section 3 of IEEE Std 334-1974, Sections 4.2 and 4.4 of IEEE Std 381-1977, Section 6.2 of IEEE Std 382-1980, and Section 4 of IEEE Std 650-1979 contain lists of information to be determined to allow specification of conditions affecting a device for qualification purposes.

Frequently, although sufficient thought has been given to the function, operating conditions, and environment of a device at the beginning of the qualification process, these details are later partially or totally omitted from the qualification report, leaving the ultimate user and any subsequent reviewers with doubts concerning the completeness of the qualification program. Proper documentation of this information greatly increases the value of the qualification and helps to assure its later value.

When a generic qualification is performed, some qualification parameters must be assumed. It is extremely important for the persons performing the qualification to give full details of the qualification specification in the qualification report. This information will allow the ultimate user of the device to determine more easily the adequacy of the generic qualification for the specific application.

3.3.1.1 Definition of Safety Function and Acceptance Criteria

Prior to beginning a qualification program or evaluating the relevance of an existing program to a specific application, the safety function for the application must be defined. This definition should include the safety function before, during, and after the design basis event (DBE) since there may be considerable differences in safety function during each of these periods. Acceptance criteria for the key parameters may also vary for each of these periods. Defining safety function and acceptance criteria adequately may reduce qualification requirements.

When generic qualification of equipment is performed, generalized functional requirements and acceptance criteria are often used. It is the responsibility of the licensee to determine specific safety functions and acceptance criteria and to verify the adequacy of the generic qualifications when they are applied to a particular plant.

3.3.1.2 Specification of Qualification Requirements

Process, power, signal, operating, and environmental conditions must be specified prior to performing a qualification program or verifying the adequacy of existing programs.

Process conditions must be known since they frequently affect the environment of the device through effects such as conduction of heat or transmission of vibration. Power conditions must be defined to allow evaluation of conditions such as low or high voltage, low and high air system pressures for pneumatic devices, or frequency variations. Expected durations of prolonged operation at the extremes of power supply conditions should also be specified. Signal conditions should be specified and any expected deterioration during accident or abnormal conditions determined. Specification of operating conditions and the operating scenario provides information about use of the device, such as continuous use or prolonged dormancy, that is necessary for proper qualification. This operational specification should include maintenance, calibration, and testing of the device since these can cause positive or negative effects on qualified life. If these effects could degrade the accident withstand capability, as in the case of seal damage when covers are removed and replaced, they may reduce the qualified life and should be taken into account before LOCA/HELB simulation.

Finally, the environments of the device for normal, abnormal, and accident periods must be defined. Safety function during accident conditions must be evaluated, since the device need not be qualified for those accident conditions during and following which it does not perform a safety function if its failure is nondetrimental to surrounding safety equipment.

3.3.2 Test Procedures

The need for test procedures is twofold. They are needed for giving direction to qualification personnel and also become an important portion of the final qualification documentation since they detail the exact steps taken during the qualification. Test procedures should adequately describe the tests performed, the test setups, and the requirements for test instrument accuracy with sufficient detail for the tester to be able to perform the test. Sections 6.3.1 and 6.3.1.1 of IEEE Std 323-1974 provide a description of the segments of the overall test procedure. More detailed procedures may be required when special test equipment or setups are necessary to qualify a particular device.

3.3.3 Test Failures, Nonconformances, and Anomalies

During the performance of nearly every qualification program, unexpected conditions and results are encountered. These range from relatively minor disturbances to failure of the test specimen. The description and evaluation of such events in the qualification report are extremely important. Events seemingly unimportant to the performer of the qualification program could be very important to the device user. Also, truly unimportant events could be miscontrued by a potential user. The device might then be rejected for use or a new qualification program inappropriately requested.

When test failures occur, the cause of the failure must be determined to be able to show whether or not qualification has been affected. There are three causes of test failure and significant nonconformances: test facility failure, test personnel error, or failure of the device being tested. Remedial action varies with the cause of the event.

When the failure or nonconformance resulted from test facility failure or personnel error, the qualification report should contain a description of the event, its effect upon the test, whether any retesting was necessary, and an evaluation of the significance of the problems associated with the test equipment in regard to the validity of the qualification program. This description is particularly important if severe temperature or pressure

excursions occurred which could have affected the performance of the devices being tested. An example is the case of an electronic transmitter which is to be tested at a temperature of 320°F and a pressure of 50 psi with an accuracy requirement of plus or minus 5% of scale. If a failure of the test equipment results in a temperature excursion to 360°F and a test pressure of 70 psi, and the accuracy of the device proves to be out of specification, then the significance of the transient must be evaluated carefully to determine whether or not the specimen failed the test as a result of the test equipment abnormality. The qualification test report should present a complete evaluation of the problem, state whether or not a retest is necessary, or show that the accuracy change resulting from the more severe transients is allowable for the application of the device.

When the test is performed as intended, but the equipment being tested fails or shows severe abnormalities in performance, the deficiency must be described and evaluated in the documentation. Some examples are:

1. An electronic transmitter is LOCA tested using IEEE Std 323-1974 profile for a PWR, and fails within the first half-hour of the test. The question in this case is whether or not the tested equipment would be suitable for <u>any</u> safety function since the failure occurred in the early stages of the test program. Testing the device at less severe conditions may allow limited usage of the device.

2. During a 30-day test of a motorized valve actuator using the PWR and BWR profiles of IEEE Std 323-1974, the actuator functions normally through the peak pressure and temperature transients during the first 24 hours, continues to function normally for 15 days, and then fails. The question which must be addressed is whether or not the equipment is qualified for an operating time considerably less than 15 days.

3. A solenoid operated valve is tested for 30 days, using the profile contained in IEEE Std 323-1974, but the solenoid enclosure seal fails, allowing boric acid spray to enter the solenoid enclosure. However, the valve continues to function normally but does not withstand specified megger testing. The appropriateness of performing insulation resistance testing at reduced voltages and its effect on qualification must be addressed.

In the case of the instrument exhibiting gross failure early in the transient period of the test, the fact that it functioned for a short period

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of time could be considered to demonstrate qualification, if the equipment is used for *immediate short-term trip functions only (i.e., safety functions* which are performed within the first few minutes of an accident scenario). However, when testing does not demonstrate that this equipment remains functional in the accident environment for a period of at least one hour in excess of the time assumed in the accident analysis, a time margin less than one hour must be justified. This justification must include, for each application of each piece of equipment, (1) consideration of a spectrum of breaks, (2) the potential need for this equipment later in an event or during recovery operations, (3) a determination that failure of the equipment after the maximum operability time will not degrade any safety function or mislead the operator, and (4) a determination that the margin applied to the minimum operability time, when combined with the other test margins, will account for the uncertainties associated with the use of analytical techniques in the derivation of environmental parameters, the number of units tested, production tolerances, and test equipment accuracies. The documentation must also include an analysis showing that the failure could not occur during the required period of operability plus the required interval of margin.

In the case of the motorized valve actuator, the test report should contain sufficient information on the nature of the failure, and the corrective action taken to preclude failure during use, so that an independent engineering determination of the ability of the valve actuator to function for extended periods can be performed. It is evident from the test results that the harsh environment during the worst period of the accident did not cause immediate failure of the valve actuator. However, long-term exposure to an elevated temperature and humidity environment subsequent to the accident condition is problematic unless the device is modified. In general, such an analysis is possible only when the cause of the failure can clearly be determined and it can be established that the failure would not occur at an earlier time. Retesting of the modifications is generally required.

It is evident that the solenoid valve continued to function and perform its safety function throughout the test period, but that special testing to

measure performance of the insulation system could not be performed due to the presence of a highly conductive solution within the solenoid housing. Such results indicate that it would be prudent to ensure that the solenoid enclosure is isolated from the environment as a precautionary measure in actual plant installation.

The persons performing qualification are encouraged to evaluate and document failures, nonconformance, and anomalies in detail at the time of detection since the persons associated with the qualification process will generally not be available at the time of review of the qualification results.

If modifications must be made to the device to preclude failure or nonconformance, the modifications must be appropriately evaluated and proof of qualification must be established by analysis or test. If only a portion of the complete qualification test is to be performed for the modified device, the rationale for performing only portions of the complete test must be documented. When a failure occurs during testing and it is believed that the failure is random in nature and would not occur on identical devices when subjected to the same test conditions, the test or portions thereof may be repeated to establish qualification. An evaluation of the cause of the failure must be presented. If only portions of the test are to be redone, the rationale for eliminating other portions must be documented.

3.3.4 Preparation of the Qualification Report

The contents of the qualification report are described in IEEE Stds 323-1974, Section 8; 334-1974, Section 8; 381-1977, Section 6; 382-1980, Section 7; 383-1974, Sections 1.4 and 2.6; 535-1979, Section 9; 627-1980, Section 7; 649-1980, Section 12; and 650-1979, Section 6. However, existing qualification reports sometimes do not address all of the pertinent information or are poorly organized, making verification of the adequacy of the qualification difficult and time-comsuming. Since the entire purpose of the qualification process is to provide documented proof that a device is qualified for its intended service, the qualification report must be given adequate attention during preparation.

The standards require that the report be presented in an auditable form. In addition, the report must be written so that an auditor or reviewer reasonably versed in the topic of equipment qualification can determine its adequacy. While it is expected that the ultimate user of the report and any other reviewers would be knowledgeable about qualification concepts and the equipment being qualified, the preparer should not expect major gaps in the report to be filled by the knowledge of the user or reviewer. Conclusions should be supported by evaluation of test data, analyses, or logical argument. The report preparer must remember that those who will read the document after its completion will not be privy to the information available during preparation.

The report should be complete, clear, and concise. In addition to the IEEE standard documentation requirements, it is suggested that diagrams and pictures of test setups be made part of the document package for each significant step in qualification. These diagrams and pictures frequently will allow the reviewer to understand test methodology more completely and will reduce the number of questions during evaluation.

A strong summary section that states the results of the qualification program should also be contained in the report, preferably at the beginning. This section should include descriptions of any major anomalies and corrective actions, as well as any modifications necessary to attain qualification. More detailed descriptions of these items should be contained in the main body of the report.

3.4 AGING AND QUALIFIED LIFE

Aging refers to a change in functional capability as a consequence of all significant stresses imposed on the equipment, the long-term effect of which is usually performance degradation. Such age-related degradation has been identified as contributing to potential common-mode failure mechanisms.

Evaluating equipment aging to establish a qualified life or an accelerated aging program requires a thorough investigation of the equipment's service stresses and potential aging mechanisms. The significance of these aging

mechanisms with respect to the equipment's functional requirements and the degradation caused by accident service conditions must be analyzed.

Each component of a piece of equipment tends to have unique aging characteristics; a simple, convenient, universal engineering model for determining age-related effects does not exist.

The following is a generalized methodology for equipment aging. Having a methodology ensures that relevant technical considerations are identified and that uncertainties that may arise in the course of an aging evaluation are addressed. Having a methodology aids in developing and supporting the engineering judgment required in most aging evaluations. Key elements for an aging evaluation may include:

- A review of equipment design
- A review of equipment materials
- Performance of a failure modes-and-effects analysis to systematically identify equipment and component functional requirements and equipment failure mechanisms significant to aging
- Identification of service stresses and aging mechanisms
- Determination of significant aging mechanisms that affect the safety function
- Use of analytical representations or models to aid in establishing qualified life and accelerated aging programs and in evaluating the significance of aging mechanisms
- Determination of a qualified life estimate
- Development of surveillance and maintenance programs to monitor equipment aging and to ensure that the qualified life is achieved.

3.4.1 Equipment Design Review

Available documentation for the equipment, including manufacturer's drawings, material lists, engineering specifications, and other technical data, should be reviewed. A thorough understanding of equipment design, construction, and function is often lacking during aging evaluation. The

details of the evaluation should be well documented since this is the main basis for the entire qualification.

Evaluation of equipment aging is multidisciplinary and may require engineering expertise in such areas as thermal and radiation degradation; seismic and dynamic requirements; equipment design, operation, and maintenance; and nuclear safety system design, including electrical, instrumentation and control, and mechanical engineering.

The practical significance of a complete equipment review is demonstrated by numerous examples of equipment that has been age-conditioned or assigned a "qualified" life on the basis of incorrect or incomplete analyses. Some evaluations only consider radiation and thermal effects and ignore stresses such as those due to operation and startup or, in the case of seals, compressive set. In some cases, a reduction in the qualified life or replacement interval may be required until a more sophisticated analysis is performed; and in others, equipment can fail LOCA/MSLB simulation tests because parts such as seals, gaskets, and lubricants are severely overaged or degraded due to overstressing during age-conditioning.

3.4.2 Identification of Equipment Materials

All component parts and materials should be identified. An inventory of all materials (including trade name and manufacturer) used in construction of the equipment should be obtained from the equipment manufacturers. Inorganic materials are customarily excluded in electrical equipment aging evaluations; however, metal and plated surfaces may require identification because age-related organic by-products (e.g., volatile or gaseous components), catalysts used in the production of organic materials, and environmental contaminants could lead to degradation of metallic parts.

Once component materials are identified, the following should be addressed: (1) potential physical and chemical incompatibilities between contiguous materials, (2) temperature limitations, including maximum use ratings, and (3) other material-related limitations (e.g., radiation, hygroscopic, and wear

properties), as stated in manufacturer materials application bulletins, engineering handbooks, and technical literature.

3.4.3 Failure Modes-and-Effects Analysis (FMEA)

FMEA is a scope reduction technique which may justify limiting qualification efforts. Interrelationships between equipment, component parts, system failures, functional requirements, environmental constraints, and surveillance and maintenance requirements can be determined by a qualitative FMEA. The FMEA procedure systematically identifies the critical components or parts of an equipment item, the failure of which could result in common-mode equipment failure. Essentially, the FMEA identifies that subset of components for a piece of equipment that requires evaluation for aging; all other components are unimportant from an aging standpoint because their failure will not result in unacceptable equipment failure.

In qualification engineering, the FMEA is customarily performed at the system level and then at the equipment level. Initially, a system-level FMEA is performed to determine unacceptable failure modes of equipment under accident conditions, i.e., those failure modes of a specific equipment item which contribute to the potential common-mode failure of the associated system. An equipment-level FMEA is then performed to determine how the postulated failure causes of individual components can lead to unacceptable equipment failure modes identified in the system-level FMEA.

A formal FMEA is not always a necessary part of the aging evaluation, especially when equipment is simple and has few components. A tabulation of component failures, resulting equipment failure modes, and the supporting rationale is adequate for most aging evaluations. In the event that all equipment failure modes are considered unacceptable, or if the equipment is simple, then a statement describing and documenting specific failure mode considerations is adequate.

3.4.4 Stress and Aging Mechanisms

The types of aging stresses specified by current regulatory requirements include temperature, radiation, humidity, wear, and vibration associated with

normal and accident service conditions. According to NUREG-0588, wear stresses include those electrical and mechanical stresses resulting from cyclic operation of equipment. Although these stresses represent the predominant concerns for most nuclear equipment, additional stresses resulting from normal operation (e.g., fault currents, cyclic stress-strain variations, and contaminated and moist environments) can contribute significantly to long-term aging degradation.

To identify the stresses that affect equipment performance requires evaluation of equipment design, functional requirements, and operating service conditions. Candidate stresses can be inductively developed from qualitative (or narrative) reliability data; industry standards related to fabrication, design, and maintenance for certain equipment items (e.g., cable, transformers, motors); engineering technical papers dealing with design and operation of equipment; and operating experience in nuclear or similar applications. These sources of information are based largely on similar operating equipment and design experience, and can be used in documenting aging evaluation conclusions. As a practical consideration, the FMEA can be used as a screening device because only stresses resulting in unacceptable age-related failures need be considered in the aging evaluation.

3.4.5 Significant Aging Mechanisms

A method adapted from Section 4.4.1 of IEEE Std 627-1980 [1] can be used to determine whether aging mechanisms have a significant effect on equipment operability.* If aging mechanisms are considered significant, they must be addressed in the development of accelerated aging, surveillance, and replacement programs, and in establishing qualified life estimates.

An age-related degradation mechanism is considered significant if the following criteria are satisfied:

1. In normal service environments, the aging mechanism promotes the same failure mode as that resulting from exposure to abnormal or DBE service conditions.

*Other methods are acceptable if reasonable assurance can be provided that significant age-related degradation mechanisms are identified.

2. The aging mechanism adversely affects the capability of the equipment to function in accordance with its specifications.

3. In normal service environments, the aging mechanism causes appreciable degradation during the design life compared to that caused by design basis events.

The above criteria provide a logical approach for evaluating potential aging effects and have been useful in evaluating diverse equipment items and aging mechanisms. The criteria are applied to individual potential aging stresses to determine if the resultant degradation should be considered significant. For those special cases where synergisms have been identified, the criteria should be applied to the combination of the aging stresses (e.g., temperature and radiation or radiation and mechanical cycling).

The use of this approach is appropriate for the evaluation of complex equipment potentially subject to multiple stresses. Simple equipment items with well-known aging characteristics (e.g., terminal blocks) do not require formal use of the evaluation criteria; however, documentation of the basis for consideration of aging mechanisms should be provided.

3.4.6 Aging Models

Aging degradation models are required to estimate the extent or amount of degradation in order to:

1. assess whether normal service operating stresses cause significant aging mechanisms in equipment

2. develop an accelerated aging basis for equipment in a qualification test program

3. establish the qualified life of equipment based on plant-specific service conditions and age-conditioning performed as part of a vendor-sponsored test program.

A review of aging in Reference 2 reveals that relatively few aging degradation models exist. These models are applicable only to a limited number of stresses and aging processes; no model exists for many practical cases of interest. Even when a model does exist, numerous factors can contribute to the uncertainty or unreliability of predictions of aging effects

in equipment. As a minimum, the following should be considered in determining the validity of predicted aging effects:

1. It may be necessary to extrapolate model results to stress levels significantly beyond the established range of the model, thereby introducing large statistical uncertainties in any aging prediction.

2. Models and associated data typically address a single aging mechanism over a limited higher stress range; changes in stress level (e.g., from test level stress used for data generation to a lower level stress associated with actual service) can result in the dominance of another competing aging mechanism. For example, Arrhenius models should not be used to quantitatively predict aging at temperatures 20° to 30°C below the lowest temperature used in establishing the Arrhenius equation parameters, unless there is empirical evidence (i.e., operating experience) that the aging mechanism is the same. e.g. (SPC

3. The physical property used to establish the model may not be easily correlated with the aging mechanism and equipment application. For example, aging data may be available only for tensile properties of a material; however, if the actual application of the material is as a seal or gasket, then compressive set is the more appropriate parameter of interest.

4. Specimens used to establish the aging model may not be sufficiently similar to the equipment under consideration. For example, cyclic failure data used in developing some accelerated aging models tend to be device-specific with little applicability to other equipment. Similarly, aging studies conducted with slabs of insulating material may not be adequately correlated to the aging of that material in its application (e.g., as conductor insulation).

5. Minor differences between the material studied and the material used in an application (e.g., difference in type or amount of filler) may cause significant differences in aging rates and even aging modes.

The methods summarized below are generally accepted to evaluate aging or to develop a basis for accelerated aging of equipment as part of a qualification test for common service stresses. Where a specific model does not exist for an application, the test method that most closely approximates the equipment aging should be chosen.

3.4.6.1 Thermal Stress

The Arrhenius model is recommended for evaluation of thermal degradation. This model is applicable to many materials and, to a first order of approxima-

tion, to some component items (e.g., certain solid state devices and motor and transformer windings). Usage is based on selection of a conservative activation energy, one of the parameters appearing in the Arrhenius equation. Although many activation energies are available in the technical literature, the specific degradation mechanism occurring over the temperature range of interest is often unspecified.

Some considerations related to thermal stress follow:

- Internal temperature rises due to self-heating effects must be included in aging evaluations. Failure to do so leads to over-estimation of qualified life or underaging of equipment during accelerated aging.

- It is common practice to use the lowest material activation energy in equipment as a conservative basis for aging evaluations. When internal or self-heating effects are considered, the activation energy corresponding to the material experiencing the maximum temperature rise often dominates aging considerations. Aging should be evaluated on the basis of each material's activation energy and actual operating temperature.

- The need for energizing during thermal aging should be evaluated. If self-heating effects are significant, energizing will result in internal temperature rise profiles that are similar to those in actual service. Energizing can reduce the likelihood of overstressing other materials because only localized equipment regions are heated and, therefore, lower accelerated-aging oven temperatures can be used.

- Application of voltage stress during thermal aging is important in aging certain devices such as semiconductors, linear integrated circuits, and certain capacitors since application of voltage stress may cause temperature rises and other stresses that would not be present in the de-energized state. In general, representative electronic circuit aging occurs only if actual operating voltage potentials are maintained in electronic equipment. Energizing of circuit assemblies during accelerated aging often requires reductions in aging temperatures (compared to unenergized circuit aging) to maintain electronic device characteristics within tolerance ranges or to accommodate device self-heating (e.g., in miniature power transformers and solid state relays). In some cases, simulated external signal levels and loads must be applied to ensure that the circuit parameters are within acceptable bounds.

- Accelerated thermal aging of an entire equipment item can result in excessive overaging of some components due to temperature and aging rate considerations. Pre-aging of components requiring greater age-conditioning exposures, followed by reassembly and final aging

with more sensitive components in the assembled equipment, should be investigated. (Separate aging of individual electronic components is not considered acceptable, e.g., transistors, resistors, etc.)

- Use of lower thermal aging temperatures and longer aging times reduces the amount of overaging of one component with respect to another; i.e., accelerated aging based on the Arrhenius model becomes more uniform as aging conditions approach operating conditions.

- Aging electronic circuits on the basis of a very conservative minimum activation energy can overage other devices beyond their useful life, resulting in failure of the circuit assembly. Temperature-dependent electronic device reliability data can be used to estimate the probability of the assembly actually surviving accelerated aging without failure. If circuit failure probabilities are too high, several circuits can be simultaneously aged for differing periods to decrease the risk of having no circuit survive aging. Alternatively, the qualified life goal can be reduced in order to increase the probability of a circuit surviving thermal aging.

3.4.6.2 Humidity Stress

There is no generalized model for evaluating humidity-caused degradation. Some assurance can be obtained that equipment is not susceptible to humidity effects by performing humidity and moisture stress tests based on those described in military test standards such as Mil-Stds 202F and 781C. (sec) In these tests, equipment is exposed to high humidity at elevated temperatures which increase vapor pressure and accelerate moisture penetration and migration. Temperature cycling performed as part of these tests intensifies humidity effects by causing condensation and subsequent transport of moisture to internal regions.

3.4.6.3 Radiation Stress

See Section 3.5.

3.4.6.4 Voltage Stress

Analytical representations are not readily available for general prediction of voltage-related degradation. Two approaches that have been used in accelerated testing include increasing voltage amplitude with constant

frequency and increasing frequency at constant voltage. The first approach is limited by dielectric breakdown considerations; the second approach can be dielectric-dependent and can accelerate certain voltage-related phenomena such as "treeing" in cable insulation. The results of accelerated voltage testing can be variable; at present there is no generalized voltage-dependent model for predicting long-term degradation. Present applications of voltage stress are primarily limited to accelerating effects during laboratory investigation of insulation.

The variation of equipment supply voltage about a nominal value (e.g., ±10%) does not provide information about voltage stress effects in the equipment. This procedure, which is common in reliability demonstration tests, ensures operability of equipment over the range of expected conditions. In the case of inductive loads, decreased voltage can result in increased load currents with subsequent increases in internal heat dissipation; stresses other than voltage (e.g., temperature, thermal expansion, or cycling) are imposed on the equipment.

For cyclic operation - subject specimen to same # of cycles? (SPC)

3.4.6.5 Operational Stress

There is no universal model for evaluating degradation caused by operationally induced effects such as actuator cycling or bearing loading. However, a simple accumulated-degradation model has sometimes been shown to be applicable to certain processes described by Arrhenius or inverse power models or more general processes with unknown degradation mechanisms. Reference 2, Section 6.4, describes this accumulated-degradation (or wear) model and several assumptions implicit in its use.

The accumulated-degradation model can be used to evaluate the degree of degradation occurring if equipment-specific data exist. Applicable data include known operating data or test data under load conditions. An important point is that the actual load conditions and, in most cases, the applicable stress must be known. The model is a simple representation of a complex process and is subject to certain basic assumptions. It should not be used indiscriminately, and the statistical uncertainty in predicted degradation should be recognized.

3.4.6.6 Vibrational Stress

It is frequently difficult to determine the expected levels of vibration to which a device may be subjected at any one location in a plant. Methods of determining hydrodynamic loads for equipment connected to piping systems have been developed; however, estimating vibration levels from surrounding heavy rotating or reciprocating machinery is not readily practicable. Some utilities have estimated expected vibration levels by measuring vibration of similar equipment in operating power plants.

Coupled with the difficulty of specifying vibration levels, acceleration techniques for normal life vibrations are generally not available. Therefore, most vibrational stress testing has been performed at arbitrary levels and durations (see Std IEEE 382-1980, Appendix D). One expected failure mode is loosening of fasteners such as bolts and clips. Fatiguing could be expected due to high-level hydrodynamic loads, but would generally not be expected for most other lower level vibrations.

Care in locating sensitive equipment away from hydrodynamic loads and reciprocating and rotating machinery will remove vibrational stress as a consideration and, for many cases, is the best way of treating non-seismic vibration.

3.4.6.7 Induced Mechanical Stress

Some electrical equipment can be exposed to operationally induced mechanical stress. Thermal expansion forces due to temperature variation caused by load changes, electromagnetic-induced vibration, and forces resulting from fault currents can produce adverse mechanical effects. For some equipment, these mechanical stresses can be more important than temperature in determining the life of an insulation system. Dielectric breakdown of a motor or transformer insulation system is comparatively rare; usually thermally degraded insulation systems fail as the result of the effects of mechanical stresses caused by operating conditions.

Currently, there is no accepted model which relates mechanical effects to service stress. The situation is complicated by the fact that these mechanical

stresses are accompanied by thermal and voltage stresses and are also, in some cases, system-dependent. Thus, even defining the applicable stress and degradation mechanism is difficult. Some assurance of long-term equipment capability can be obtained by exposing the equipment to repeated overstresses as part of an accelerated aging program. For example, penetrations and dry-type transformers can be subjected to overcurrent stresses corresponding to the estimated fault current frequency, magnitude, and duration expected over the qualified life of the equipment.

3.4.7 Qualified Life

Under current regulatory requirements, it is essential to establish a qualified life for each item of safety equipment.* Qualified life is basically the longest period of service at the end of which the equipment is still capable of performing its specified function if a DBE occurs. Determination of qualified life entails evaluation of past operating experience; data on material and component degradation under the expected service stresses; the specified inspection, calibration, and maintenance procedures and their ability to maintain the functional capability of the equipment; and the ability of surveillance procedures to detect the amount of degradation that has occurred, as well as results of the aging program. Qualified life predictions which are based solely on Arrhenius models of thermal degradation and ignore the effects of other stresses that tend to decrease qualified life are technically unjustified. SRC

Recommendations for estimating qualified life for some common cases are as follows:

1. Qualified life can be estimated by the Arrhenius equation and cumulative damage model (c.f., Section 6.3, Reference 2), if temperature is the only significant stress affecting aging. The Arrhenius model should not be used to quantitatively predict aging at temperatures which are 20° to 30°C below the temperatures used to establish equation parameters, unless operating experience exists which confirms the validity of the extrapolation.

*The component replacement schedule in Section 7 of the DOR Guidelines is essentially a qualified life. This replacement interval must be justified.

2. Where multiple aging stresses exist but one aging mechanism clearly dominates, qualified life based on this mechanism is appropriate, provided a valid aging model exists and synergisms are not present.

3. Where multiple aging stresses exist and minimal (or insignificant) aging is expected for each stress, a long qualified life would be expected. *could be manufacturer's design life (SPC) — monitoring in-service would reveal any combined environment effects. (SPC)*

4. Where multiple aging stresses and multiple aging mechanisms have been determined, conservative engineering judgment must be used in establishing qualified life. Engineering judgment must be documented and supported by evidence of extensive technical review. Some practical considerations which may aid in determining a reasonable qualified life are:

   o It may be possible to evaluate the effect of multiple aging stresses in sequential order rather than evaluating their simultaneous effect. The order chosen would have to lead to equal or greater degradation than that resulting from simultaneous stresses. The qualified life established on this basis would be conservative, although engineering judgment may still be required.

   o If an age-related stress is specifically included in the functional design basis of the equipment by the manufacturer, or is addressed by industry production test standards, it may be possible to consider this stress secondary in importance relative to other equipment stresses. *— but how does one accelerate aging? SPC*

   o Routine maintenance and inspections performed on equipment should be considered. If components are routinely replaced as part of these actions, it may be advantageous to accept simultaneous replacement of other potentially age-sensitive components. Essentially, detailed aging evaluation and surveillance requirements are traded off in favor of a shorter, more convenient, and more conservative qualified life.

   o Qualified life can be initially established on the basis of measurable changes in equipment surveillance parameters such as insulation resistance, signal and circuit levels, closing time, leakage rates, and drift and recalibration frequency. Essentially, equipment is considered within its qualified life if it is in "like new" condition. This approach does require operating experience to establish an initial qualified life estimate. The rationale used to establish the qualified life could be used to extend this value if future experience indicates that no measurable changes in surveillance parameters occur.

   o Changes in the types of non-burn-in failure modes and mechanisms experienced by equipment can be used to develop an initial

qualified life. Complex equipment usually experiences several competing failure processes over its life span. A conservative approach is to initially limit the qualified life to the "like new" operating region based on qualitative review of the type of failure occurring.

- If reliability data indicate that random equipment failures can be expected frequently over plant life, and if repair is by replacement of the entire failed unit, then a conservative qualified life could be estimated on the basis of expected failure frequency. There is little value in performing a detailed evaluation of long-term aging effects if chances are that the equipment will have to be replaced prior to this time.

3.5 SIMULATION OF RADIATION EFFECTS DURING NORMAL AND ACCIDENT PERIODS

Simulation of real-time radiation degradation during qualification is empirical rather than a rigorous engineering effort. Many questions concerning test sources energies and dose rate effects remain to be answered. However, as a practical matter, qualification of equipment cannot wait for complete answers to these questions. Sound engineering judgment and evaluation is necessary to preclude major errors in radiation effects simulation or use of inappropriate testing methodology.

The following information is provided as a basis for such considerations.

3.5.1 Radiation Aging Simulation for Normal Service

Radiation aging is intended to determine if a radiation threshold effect exists and is significant. The radiation threshold is the lowest dose which causes a permanent change in a measurable physical property of a material of interest to the application. For most organic materials, radiation-type and energy effects are minor, and therefore an "equal dose-equal damage" concept is employed. In this approach, the radiation effect is assumed to have a limit below which degradation is usually not important.

Radiation aging considerations include the following:

- Determine the aging dose required for the equipment based on the expected service environment and qualified life.

- Investigate equipment materials to determine whether dose-rate effects are known to be significant. Radiation thresholds are typically determined with cobalt-60 gamma radiation at dose rates of less than 1 Mrd/h, but at a value greatly exceeding normal service environments for organic materials in nuclear equipment.

References 4 and 6 provide some data for this evaluation.

3.5.2 Shielding Considerations for Beta Doses

It is known that the equipment enclosure can sometimes provide considerable shielding to radiation such as beta particles.

If the thickness of the enclosure is greater than or equal to the maximum range (see Table 3-1) of the incident beta radiation, the dose contribution from beta may generally be ignored. There still will be doses from secondary photons (Bremsstrahlung) due to electron interaction; however, this dose is less than a few percent of the incident dose.

3.5.3 Simulation of Beta Radiation Effects

Since electron beam machines usually have relatively small diameter beams and single envelopes, it is not practical to simulate the actual environment conditions encountered in the plant. The alternative is to simulate the radiation effects by gamma rays. This technique is accepted as a qualification practice. It is generally believed that use of gamma will not result in large discrepancies.

3.5.4 Rate Effects

IEEE Std 278-1967 and ASTM D2953-71 give formulas for calculating equivalent doses applied at different rates. However, the former standard has been withdrawn and the latter has limited applicability.

For thin insulating materials, where oxidation reactions are pertinent, and the rate of oxygen diffusion into the material is a controlling factor, accelerated irradiation at a high dose rate may not adequately simulate the degradation that takes place over many years at a low dose rate. (For

Table 3-1. Electron Ranges in Materials for Energies from 0.1 MeV to 5 MeV for Beta Shielding Evaluation

		Range* (cm)					
	Density	Electron Energy (MeV)					
Material	(g/m^3)	0.1	0.5	1.0	2.0	3.0	5.0
Al	2.7	5.0 E-3	6.1 E-2	1.9 E-1	3.7 E-1	5.5 E-1	6.1 E-1
Fe	7.9	1.7 E-3	2.1 E-2	6.6 E-2	1.2 E-1	1.9 E-1	2.1 E-1
Pb	11.3	1.2 E-3	1.5 E-2	4.6 E-2	8.4 E-2	1.3 E-1	1.6 E-1
Air	1.29 E-3	1.1 E+1	1.3 E+2	4.0 E+2	7.3 E+2	1.2 E+3	1.3 E+3
Poly-ethylene	1.0	1.3 E-2	1.6 E-1	5.2 E-1	9.5 E-1	1.48	1.64

*Calculated from the energy-range relationships given by Equations 3.3 and 3.4 of Reference 5.

Note: Exponential format 5.0 E-3 equals 5.0 x 10^{-3}.

example, Reference 6 reports on Japanese research into dose rate effects on the degradation of polymeric insulating materials.)

Under many conditions, experiments have shown that radiation effects depend primarily on the total amount of energy absorbed by a material and only secondarily on the rate. More recent experiments have shown significant dose rate effects at low dose rates [7].

In qualification, the simulation of radiation aging is done at rates much higher than the in-service rates, and the simulation of accidents usually involves the use of dose rates lower than those that apply at the beginning of an accident. At this time, it appears that practical considerations must override the concerns for dose rate; however, sound engineering judgment must be exercised to preclude arbitrary dismissal of dose rate effects.

Some dose rate information was encountered during the review which included more than 100 separate test reports on electrical cables. The major insulation materials used as the cable test samples were cross-linked polyethylene, chlorosulfonated polyethylene, ethylene propylene rubber, neoprene, butyl rubber, and silicone rubber. Proprietary flame-retardant additives and layered combinations of insulating materials and shield were also used by various manufacturers to provide special features required by licensees and their engineering contractors.

Testing typically involved irradiation up to 200 Mrd at dose rates between 0.1 and 2.1 Mrd/h. Measurements of insulation resistance during the tests indicated that cable insulation resistance decreases with increasing dose rate, and the insulation resistance recovers after the exposure ceases. Typical reductions in insulation resistance were:

from 10^{11} to 10^{8} ohms at the low (0.1-0.25 Mrd/h) dose rates
from 10^{11} to 10^{5} ohms at the higher (1-2 Mrd/h) dose rates.

There are insufficient test data to determine the mathematical relationship between insulation resistance and dose rate. There is, however, test evidence that the dose rate effect combines with the pressure, temperature, humidity, and spray effects to further reduce insulation resistance. For very high dose rates (i.e., greater than about 2 Mrd/h) during simulated LOCA

conditions, insulation resistances as low as 1000 to 10,000 ohms for 30 ft of cable (measured at 10 V dc) have been experienced.

For postulated LOCA conditions, the dose rates calculated for a nominal 1000 MW(e) plant using NRC recommendations are typically 1 to 3 Mrd/h gamma and 10 Mrd/h beta during the first 10 hours of the LOCA. It can be seen that the LOCA dose rates for insulation subject to beta radiation exceed most test radiation dose rates by an order of magnitude.

There is concern, therefore, that exposed cables (i.e., cables not protected from beta radiation by cable tray covers or conduit) will not retain high enough insulation resistance to transmit reliable control and instrumentation signals without attenuation and distortion during the early stages (the first 10 hours) of a LOCA.

The licensees of plants with exposed cables should carefully evaluate the possible effects of combined gamma and beta radiation dose rates, plus elevated temperature and moisture, on the ability of the cables to perform their functions.

3.5.5 Monitoring During Irradiation

During accident radiation simulation, whether combined with aging irradiation or performed separately, monitoring of electrical and electronic devices and cable insulation systems is of great importance. Dose and dose rate effects may cause degradation, erratic operation, or complete cessation of operation during irradiation. This situation could be self-correcting and therefore not detectable during post-irradiation functional testing.

3.6 POSTULATED ACCIDENT SIMULATION

Simulation of design basis events and accidents such as LOCAs and MSLBs has been part of qualification testing since the earliest qualification efforts. Aging and seismic testing were added to the testing sequence later. In general, accident simulation is relatively well understood and attempts to model the specified service conditions as well as possible. However, the following concerns should be addressed prior to attempting a qualification.

1. How adequately has the accident profile been specified? Is it over-conservative, leading to possible equipment failures? Or is it under-conservative, leading to an invalid test? Have submergence, spray, and containment atmospheric conditions been properly specified?

2. If long duration post-accident operability is required, will the containment atmosphere be adequately simulated in the LOCA chamber? Of primary concern is the oxygen level expected in the containment since many organic material interactions involve oxygen. The actual containment may be oxygen rich or oxygen poor, depending on inerting systems and other hydrogen control systems used. The LOCA chamber may have had its oxygen purged at the start of the simulation. This may not model the oxygen level expected during long-term operability testing. The oxygen level in the test chamber is particularly important when acceleration of the post-accident operability period is attempted since the Arrhenius model is based on chemical interactions, of which the oxygen reactions are of prime importance.

3. The test setup must closely model the actual mounting and orientation of the device with sprays appropriately directed at the device.

4. *Interfaces (see Section 3.7) must be appropriately modeled during the* test.

5. Margins must be considered (see Section 3.8).

3.7 INTEGRATION OF INDIVIDUAL DEVICE QUALIFICATIONS INTO A QUALIFIED SYSTEM

Qualification in the nuclear industry is performed on a device-by-device, rather than system, basis. Because of this, the interconnection of equipment (i.e., interfaces) must be carefully considered during simulation of normal service and accident service conditions. For example, when an electronic transmitter and the associated receiver are qualified independently, their interconnection must be carefully scrutinized. If the transmitter is in a harsh environment, its output signal and accuracy may be degraded. The interface, including the interconnecting cabling system, will also have degraded properties. Therefore, the signal received by the receiver may be inadequate. For this reason, those specifications of acceptable signal levels at the output of the transmitter and input of the receiver must be carefully determined so that qualification personnel can determine whether the equipment performance during testing has been adequate.

Such interface problems as seal failure at interconnections, dissimilar material interactions, structural adequacy, and loadings must also be considered.

Interface with non-safety-related equipment must also be evaluated. This may not be totally possible at the time of qualification. Non-safety equipment can fail in a manner detrimental to the safety equipment. Good design and engineering practices coupled with proper plant housekeeping must be effected to preclude such problems.

3.8 MARGIN

IEEE Std 323-1974 states, "Margin is the difference between the most severe specified service conditions and the conditions used in type testing to account for normal variations in commercial production of equipment and reasonable errors in defining satisfactory performance." The meaning of margin in this context is further elaborated by the following statements based on a recollection of the deliberations of the IEEE Working Group and Subcommittee that produced the standard.

Some of the concerns of the IEEE Working Group and Subcommittee were:

1. The margin required by the standard is intended to be in excess of any margins included in the design of the plant equipment.

2. One of the reasons for requiring qualification margins is that most qualification testing is conducted with a single specimen, and it is recognized that the test specimen could be superior in functional capability to some of the equipment items (represented by the test specimen) installed in the plant. Therefore, test results can indicate better functional capability than that which can be expected in the plant. It may be inferred that testing more than one specimen of a given equipment item can justify a reduction of that portion of qualification margin intended to account for "normal variations in commercial production of equipment."

3. The values of margins listed in the standard are "suggested" values. The large variety of equipment and applications is inconsistent with the specification of generally applicable margins.

The margins used in qualification testing are to be added to the margins used in design. If inadequate margin is found to exist between an existing

qualification result and the specified requirements for the application of a device, the design margin can be reevaluated to determine if it can be reduced while retaining adequate conservatism. Such reevaluations of design margin for use as qualification margin must be quantified and documented.

The suggested values of margin in IEEE Std 323-1974 may be overconservative or underconservative for a particular application. In one example involving a frequency and voltage regulated power supply, qualification to lesser margin values is appropriate for the powered device. If the power supply is regulated to ±0.1% of rated frequency and voltage, a margin such as 1% may be appropriate. In such an instance, an analysis of the effects of such variation could eliminate the need for adding margin during testing.

Time margins should be carefully considered, especially in relation to other parameters such as temperature and pressure. When an accident simulation chamber cannot duplicate the slope of the temperature profile conservatively, additional peak temperature margin could be considered. Increasing the slope of the temperature transient (reduction of time is conservative in this case) is a margin, although it is extremely difficult to quantify.

Use of Arrhenius aging concepts in conjunction with operability period time extrapolation of LOCA chamber test durations and margin evaluations may lead to erroneous results. Many accident simulations exhaust the chamber oxygen when steam is introduced. The lack of oxygen severely limits the applicability of the Arrhenius technique since many of the organic material aging reactions are oxygen-based. Thus, to state that margin exists because an additional hour at the peak temperature equates to many hours of accident duration at lower temperatures is generally technically unsupportable. Aging techniques are allowable for long post-accident operability applications if properly performed. Acceleration of the accident simulation or taking credit for long elevated temperatures should be carefully evaluated to assure applicability of the Arrhenius technique.

While determining margins for specific applications may be difficult, use of engineering judgment is of value to determine the applicability of the suggested margins of IEEE Std 323-1974.

Margin when applied to parameters specified with tolerances must be carefully evaluated. A power source voltage specified as 120 Vac ±10% indicates that the range of voltage is 108 to 132 Vac, which does not include margin since these are actual voltages that can be expected. Margin must be added to these values to prove the adequacy of the device. The judgment of whether or not the IEEE Std 323-1974 margin value of ±10% is applicable must be made by the performer of the qualification. It is recognized that 120 Vac ±20% may not be appropriate for the testing of many devices. The margin value chosen must be appropriately evaluated.

The application of multiple margins simultaneously must also be carefully evaluated. Margin should be simultaneously applied when conservatism of separately applied margins cannot be demonstrated.

As an example, application of margin on the temperature profile with the simultaneous application of margin on the lower limit of power supply voltage to a motorized valve actuator would be appropriate during the onset of the accident simulation since there would be a high probability of low voltage at that time due to start-up of large motors in the actual application. There would also be a demand for operation of many motorized valve actuators. IEEE Std 382-1980 includes this concept in Figures 4 and 5, Note 5; and Figures 6 and 7, Note 9.

3.9 EVALUATION OF A GENERIC REPORT FOR A SPECIFIC APPLICATION

Frequently, generalized or generic qualification tests have been performed. Devices are generally tested to their limits or to the highest expected qualification values expected for existing plants and those under construction. The user must then evaluate the results for his specific application.

If all applications of a device were similar or identical, this approach would be easy to implement. Frequently, however, new applications of a device or different service conditions from those simulated during testing are encountered. The user of the qualification must then evaluate the existing qualification against his needs and determine whether further qualification is necessary.

The evaluation of a generic program for a specific application must be orderly and documented properly since it is a major portion of the qualification of the device for its specific application. A specification for the application should be prepared and compared to that of the generic qualification. Any nonconservative differences must be evaluated and the appropriate testing or analyses performed. This entire effort must be fully documented and made part of the documentation file for the device.

It should be noted that, for any device used repeatedly in a plant, a plant-wide specification using the most conservative qualification parameters from each application could be developed and a single review of the qualification documentation performed. There are some limitations to this approach; one is that a device may be qualifiable for the separate applications, but not for the summation of the separate application parameters. Another limitation is that the variations in normal environments at particular places in a plant could cause significant differences in aging rates, making a separate aging evaluation appropriate for each device. These separate evaluations would preclude replacing all devices on short intervals based on the least benign normal environmental conditions.

3.10 SIMILARITY ANALYSIS

In certain cases, there are small differences from one model to another in a manufacturer's product line with respect to equipment qualification, and it may be possible and practical to use the test results from one model as a basis for qualification of the others. The similarity of one device to another must be closely evaluated, since even minor differences could cause significant differences in the ability of a device to withstand the service conditions. The manufacturer must be the same, and the same quality assurance program should be in place during manufacture. It should be noted that production variations from division to division of a manufacturer have caused qualification problems.

The following excerpt from IEEE Std 381-1977, in which the word "device" is substituted for "module," sets forth concisely the requirements for similarity analyses and evaluations:

"A type test for the purpose of qualification of a specific device may be considered to be representative for qualification acceptance of a similar device containing similar materials, similar components, similar functional performance characteristics, similar construction, and similar service ratings, and fabricated by the same manufacturer with similar procedures. Justification must be provided for such qualification by analysis. The following points, among others, may be considerations in establishing adequate justifications:

1. Component physical arrangement; size, mounting features, interconnections, stresses, heat generation/dissipation, and electromagnetic susceptibility

2. Aging effects

3. Environmental effects

4. Performance requirements

These considerations may make extrapolation appear difficult, but justification for many devices of the similar design can be acceptably achieved. These cases with adequate documented justification will be considered as having qualified by analysis."

When different but similar materials are used, the differences in material properties should be closely evaluated since minor chemical differences may cause significant variations in material properties. Wide variations in radiation withstand capability, dielectric strength, thermal aging properties, and chemical interaction with surrounding materials have been noted due to material differences in seemingly similar materials.

SPC

3.11 VERIFICATION OF QUALIFICATION RESULTS DURING OPERATION (MONITORING OF ACTUAL DEGRADATION)

A qualification verification program is required: (1) to monitor in-service aging, (2) to verify that the assessed qualified life including the technical bases is reasonable, and (3) to provide assurance that all significant aging mechanisms have been considered.

The equipment parameters surveyed by the verification program must be keyed to detecting potential changes in equipment performance caused by significant aging mechanisms. The equipment parameter(s) chosen should be capable of providing an indication of cumulative aging degradation or a threshold

which, when exceeded, alerts operating personnel of potential unacceptable degradation of equipment. This effort is a degradation monitoring program, and differs in scope from periodic demonstration tests such as the monthly start-up and 15-minute run of an auxiliary feedwater system pump. Periodic testing demonstrates only operability at the time of the test and provides little information on equipment performance under DBE conditions near the end of qualified life.

A well-planned preventive maintenance program can help maintain equipment qualified life. Preventive maintenance actions should particularly address those aging mechanisms which affect the ability of the equipment to perform its safety function and should ensure that the degraded components and materials are refurbished or replaced as necessary to maintain qualification. The balance of preventive maintenance actions, such as realignment and recalibration, are designed to keep equipment performance within specifications.

The methodology for the study of equipment aging described in Sections 3.4.6.1 to 3.4.6.7 provides a basis for the selection of suitable parameters for verification and preventive maintenance actions; i.e, a thorough review of equipment design, applicable failure modes, service stresses, and aging mechanisms is required to ensure that selected verification and maintenance techniques can provide assurance that aging mechanisms do not compromise equipment function.

General considerations in establishing verification and preventive maintenance programs for monitoring and maintaining qualified life follow:

- Use the generalized aging methodology as an aid in establishing and documenting the technical bases for the selection of equipment verification parameters and preventive maintenance actions.

- The number of verification parameters required for each equipment item should be minimized, yet should cover all significant aging mechanisms. With judicious selection, one or two parameters may be sufficient to monitor multiple aging processes. Aging technology is limited, and the selection and measurement of many parameters for a piece of equipment may not be warranted. The parameters should be chosen with the objective of "flagging" age-related concerns in order to initiate follow-up investigations.

- When possible, the verification parameter selection should emphasize those parameters which can be conveniently included as part of normal calibration, equipment test, and preventive maintenance procedures to minimize additional inplant actions.

- Verification programs can usually be integrated into existing preventive maintenance or testing programs by modification of plant procedures as required. Surveillance parameter data can be recorded by expanding preventive maintenance and test program record format.

- A verification technique does not have to be exotic or require sophisticated methods. Visual inspection coupled with minor preventive maintenance actions may be the only practical means of ensuring that significant aging effects do not occur, especially in simple equipment items such as terminal blocks.

- An engineering review of the verification data should be periodically performed by personnel familiar with the equipment and the equipment qualification aging evaluation. Since electrical equipment is likely to be maintained and monitored by several organizations (e.g., plant operations, electrical maintenance, instrument and control maintenance, and testing groups), an interdisciplinary group should be established to ensure adequacy, consistency, and continuity of the periodic reviews.

- In-plant failure data can supplement verification programs in evaluating aging. Evidence of increased failure or corrective maintenance rates and resultant failure modes may provide additional indication (with surveillance data) of wearout processes resulting from aging mechanisms. Although indication of increased failures or failure rate can provide evidence of age-related degradation in populations of equipment items, it is not adequate as a sole means of monitoring these effects. If observable increases in failure rates are relied on for detecting age-related phenonomena, significant aging may already have occurred in equipment, thereby increasing the potential for common-mode failure under abnormal stress conditions. Relying solely on observable increases in the number of failures as a means of monitoring age-degradation can make initial detection difficult, especially when equipment populations have mixed ages.

4. DISCUSSION OF EQUIPMENT DEFICIENCIES

4.1 GENERAL

The following discussions pertain to findings noted during the review of environmental qualification of safety-related electrical equipment for 71 operating power plants. The scope of the review included evaluation of all documentation submitted by the licensees pertaining to the qualification of this equipment. All information was evaluated from an independent technical position. The conclusions concerning each equipment item were based on the technical information provided by the licensee in accordance with the appropriate NRC requirements. In this section, the requirements leading to the finding, a discussion of the deficiency, and some possible solutions are given. The solutions provided are by no means exhaustive. They are presented here to highlight some of the more direct resolutions. Many of the resolutions have been used repeatedly throughout this section for the various deficiencies. In all cases, the considerations presented in Section 3 should be used. Sound engineering rationale and judgment should be applied to all resolutions to achieve long-term results. "Quick-fix" solutions should be avoided because they will generally result in the eventual expenditure of more staff-hours and money.

4.2 ADEQUACY OF DOCUMENTATION OF QUALIFICATION

4.2.1 Requirements

DOR Guidelines, Section 8
NUREG-0588, Categories I and II, Rev. 1, Section 5

4.2.2 Description of the Deficiency

The most common deficiency encountered during the review of environmental qualification of safety-related electrical equipment was inadequately documented evidence of qualification. Most of the problems encountered fall into the following categories:

1. *Complete absence of documentation:* For many types of equipment purchased prior to and during the early 1970s, standard, "off the

shelf" items were procured to functional specifications. Purchase of highest quality industrial equipment was considered adequate for qualification purposes. Documentation of tests or analyses for qualification purposes was frequently not considered necessary. Equipment in this category included solenoid valves, electronic instrumentation, pump and fan motors, and various switching devices (e.g., pressure, temperature, level, position switches).

2. Documentation that provided general information but no data on environmental qualification. Vendor catalogs, sales brochures, technical manuals, parts lists, and operating instructions were frequently cited as evidence of environmental qualification. Such documents may be useful for evaluation of equipment capability in normal ambient conditions but usually contain no data on performance in the harsh environments resulting from a LOCA or HELB.

3. Documentation consisting of a "test summary." For some equipment, several licensees cited test summaries prepared by NSSS suppliers, manufacturers, or architect-engineers as evidence of qualification. These documents do not usually provide data which can be evaluated by an independent reviewer but merely assert that a test was performed under harsh conditions and that the equipment performed adequately. The sources of the information, the agency performing the test, and actual test information are not provided in the test summary. Therefore, the test summary does not provide an auditable record.

4. Certificates of Compliance (C of C): Although specifically identified as being inadequate for proof of qualification by NUREG-0588 and DOR guidelines, in several instances C of Cs were cited as evidence of qualification with no other supporting documentation. (Note: This deficiency does not apply to manufacturer certification of the applicability of a qualification test report to equipment furnished for a plant. The deficiency reflects use of a C of C in place of all other qualification documentation.)

4.2.3 Resolution

4.2.3.1 Alternatives for Devices in Containment Subject to and Required to Function During LOCA/MSLB

1. Determine from the manufacturer, NSSS supplier, other members of utility groups, if any testing has been performed which would establish qualification for the plant conditions. The licensee must then verify that the testing applies to the actual equipment installed and the conditions postulated.

2. Replace with qualified equipment. (This is the resolution most commonly identified by licensees.)

3. Review the equipment design to determine if the item is likely to be qualified by test and then perform testing which envelopes the plant conditions.

4. Some manufacturers offer part replacement kits to upgrade older designs to meet current qualification standards.

4.2.3.2 Alternatives for Devices Outside Containment Subject to and Required to Function During LOCA/MSLB

1. Determine from the manufacturer, NSSS supplier, other members of utility groups, whether testing has been performed which would establish qualification for the environmental conditions to which the equipment is exposed.

2. If the equipment is subject to steam exposure, testing which envelopes required pressure and temperature conditions is the preferred method of qualification; however, sound engineering analysis coupled with partial testing may be adequate. NUREG-0588 states:

   "Although actual type testing is preferred, other methods when justified may be found acceptable. For environmental qualification of equipment subject to events other than a DBA, which result in abnormal environmental conditions, actual type testing is preferred. However, analysis or operating history, or any applicable combination thereof, coupled with partial type test data may be found acceptable, subject to the applicability and detail of information provided."

   In response to comments on NUREG-0588, the NRC provided the following caveat:

   "Resolution 51 - (2.1(3))

   For electrical equipment located inside or outside containment that may be exposed to high energy line breaks (for example, LOCA, MLSB, feedwater line rupture), analysis alone is generally inadequate to demonstrate functional operability such as accuracy or response time, or to verify seal integrity (as in connectors), or even to detect intermittent or spurious failures. Although some analysis may be used when the testing is the principal qualification method, that analysis should be limited to extrapolations of data or to analyzing similarities in equipment or materials. In either case, analytical assumptions should be verifiable or supported by test data.

   Recognizing the complex interaction of the environment on materials and equipment (such as aging or simultaneous vs. sequential effects) the staff does not agree that analysis by

itself is an acceptable alternative for qualifying equipment required to function in the above-mentioned hostile environments. (See exceptions in Section 2.4)."

Functional performance should be monitored during testing. The above comments on analysis should not be construed as precluding thermal response analyses to establish validity and applicability of existing test data or reasonable extrapolations of test data and test duration.

3. If the equipment is subject only to radiation exposure as a result of the accident, analysis would be an acceptable method of qualification for relatively simple equipment such as cables, limit switches, small transformers, and similar devices. However, for instrumentation, functional performance and accuracy may be impaired under irradiation. Analytical techniques are not adequate for such equipment, and testing at a total dose which envelopes the accident condition is necessary. The dose rate should be as close to that of the simulated event as practicable since instrumentation is frequently dose-rate sensitive.

   If radiation testing is performed, functional behavior during and after irradiation should be monitored. See Sections 3.7.2 and 4.12 for further discussion of radiation testing and analyses.

4.3 SIMILARITY BETWEEN EQUIPMENT AND TEST SPECIMEN ESTABLISHED

4.3.1 Requirements

NUREG-0588, Section 5(1)
DOR Guidelines, Section 5.2(2)

4.3.2 Description of Deficiency

The second most common deficiency identified in the EEQ evaluation program was the failure of the licensee to establish that the installed equipment was the same as the equipment which was qualified.

Usually the relationship of the type or model of the installed units to the type or model of equipment which was tested could not be determined from the information presented by the licensee. In general, the following problems were encountered:

- The System Component Evaluation Worksheet (SCEW) sheet did not contain sufficient information to adequately describe the installed equipment. This most commonly occurred with electrical cable.

The similarity between the test samples and the installed device is particularly important for cable and devices with complex insulating systems such as large motors. Generally, the manufacturer's description of the insulation system tested is very explicit. Cable manufacturers cite such things as conductor size and tinning, insulation material and flame retardancy, binder tape materials, shielding material and configuration, and jacket material. When a licensee cites only a small portion of this material, it is not possible to determine the applicability of the tests. Minor differences in cable design or materials can cause totally different qualification results.

Motor similarity problems are similar to those noted for cable. Motor manufacturers are very explicit in their description of the test motor and provide a description including such things as the size and style of frame, horsepower, winding insulation, bearing system, and heat exchangers. If the licensee provides only a portion of this information or provides a description which differs in frame style, size, horsepower, and insulation system, without providing an evaluation of the differences, a review must conclude that the test report does not apply.

- o The SCEW sheet identified a model number which was different from the model identified in the referenced qualification document. No analysis of the similarities or the differences between the installed and qualified equipment was provided. This deficiency is common to transmitters, electric motors, solenoid valves, and miscellaneous equipment such as pressure switches, temperature switches, and differential pressure switches.

- o Within the qualification documentation package supplied by the licensee, documentation from the manufacturer certifying that a particular test report applies to the installed equipment was frequently lacking. This is a common problem with valve actuators, cables, power-operated relief valves, and similar equipment in which product improvements have taken place over a period of time and data are needed from the manufacturer to establish which particular qualification document will apply to the equipment furnished for the plant.

- o In some cases, manufacturers identified equipment by a particular coding or tag identification for the laboratory performing a test. In many cases, no further identification was provided, and the test report merely contained tag numbers or a special identification code provided by the manufacturer. This is usually insufficient to establish a link to installed equipment without specific documentation from the manufacturer.

- Frequently, tests were conducted on equipment with special modifications such as seals, special gaskets, or special conduit sealing materials. These were usually provided to ensure that the equipment passes the test; however, such sealing devices or special features may not be supplied by the manufacturer for equipment to be installed in the plant, and the equipment may not be qualified without the specific interface being identified and qualification of that interface being established. Typical of equipment in this category are limit switches, solenoid valves, and electronic transmitters.

4.3.3 Resolution

In general, the resolution of this particular deficiency would most easily be accomplished by obtaining from the manufacturer certification that the equipment supplied for installation in the plant was qualified by a specific test report (ID number and date), conducted by a particular test laboratory or manufacturer. The manufacturer should identify the specific item or items in the report which provide the evidence of qualification for the installed equipment and the basis for such qualification. As an alternative, a similarity analysis could be performed (see Section 3.9).

4.4 EVALUATION OF AGING AND ESTABLISHMENT OF QUALIFIED LIFE (Refer to Section 3.4.7 for discussion of qualified life and replacement schedules)

4.4.1 Requirements

DOR Guidelines, Section 7
NUREG-0588, Section 4

4.4.2 Description of Deficiency

Deficiencies associated with age-related degradation were identified in several areas. Briefly these are as follows:

Aging effects were generally not addressed or addressed in a manner not adequate for the conditions involved. Some typical problems and possible resolutions are discussed below. In general, where analyses were performed, they were performed using the Arrhenius method or the 10°C rule. Where the Arrhenius method was used, activation energies were selected from a variety of sources. In only a few cases was the activation energy information applicable to the property of interest and the mode of failure involved in the equipment being analyzed.

1. One of the common deficiencies identified was the use of activation energy data which would forecast the longest possible life as opposed to conservative data which may predict a shorter life but would be more realistic for most organic materials used in electrical equipment. Typically, if an elastomer was discussed in three source documents and activation energies of 0.7, 0.9, and 1.15 eV were found, the highest activation energy, i.e., 1.15 eV, would be used in the calculations, thereby predicting life far in excess of 40 years as opposed to using the lower bound value and perhaps calculating a lifetime in the neighborhood of 15 to 20 years. Good engineering judgment would indicate that elastomers having lifetimes in excess of 40 years are the exception rather than the rule and that normally elastomers would have considerably shorter useful or qualified lifetimes. The resolution to this problem is to select a conservative lifetime, and include the equipment in the plant surveillance program if the property which tends to degrade is detectable by nondestructive testing and surveillance.

2. Another common deficiency identified in the forecasting of age degradation of transmitters or other electronic devices was assigning a composite activation energy for the electronic assembly by eliminating many of the devices as not safety-related without performing a failure modes-and-effects or other form of analysis which shows such methodology to be conservative. Such an evaluation would be required to resolve this deficiency.

3. Another frequently encountered aging problem involved taking recommended replacement schedules supplied by manufacturers based on a given ambient temperature and using the Arrhenius technique to forecast longer lifetimes and therefore longer replacement schedules because of reduced ambient conditions. Usually the manufacturer was not contacted to determine the exact basis of the predicted lifetime. The resolution to this problem is that if lifetimes supplied by the manufacturer are to be extended, the basis for extension should be verified by the manufacturer as well as by theoretical calculations.

4. The third most common problem associated with aging analyses was the extrapolation of LOCA simulation tests which involved steam exposure, and in some cases simultaneous steam and radiation exposure, to forecast lifetimes of the equipment. In many cases, testing was conducted using profiles recommended in IEEE Standards, whereas actual profiles were lower in temperature but of longer duration. Attempts have been made to use the Arrhenius technique to forecast qualified lifetimes by evaluating the margins between actual accident profile and test profiles. The validity of this technique must be carefully considered when oxygen has been exhausted from the test chamber. See Section 3.6. SPC

5. Frequently, aging analyses were provided that addressed only thermal effects. No discussion or documentation was provided concerning effects such as voltage surges from power cycling, wear from operation of the device, humidity, or process variations. The resolution of a deficiency of this nature would involve analysis or testing of those effects. See Section 3.4 for further description of aging concerns.

4.5 SIMULATION OF AGING

4.5.1 Requirements

NUREG-0588, Section 4

4.5.2 Description of Deficiency

This deficiency applies only to NUREG-0588 Category I requirements. Deficiencies regarding simulating aging were identified only if a piece of equipment which required compliance with NUREG-0588 Category I had not been aged prior to LOCA simulation testing. This deficiency was not frequently encountered. Inadequacy of the aging analyses or simulation resulted in deficiencies such as those noted in Section 4.4. In general, the licensees governed by NUREG-0588 Category I requirements responded to the NRC's concern and indicated development of a program presently in progress, modifications to existing programs, or a general acknowledgment of the concern regarding aging degradation, and stated positive action to resolve the problem would be taken.

4.6 SIMULATION OF ACCIDENT TEMPERATURE AND PRESSURE PROFILE

4.6.1 Requirements

DOR Guidelines, Sections 4.1 and 4.3
NUREG-0588, Sections 1.1, 1.2, 1.3, and 2.2

4.6.2 Description of Deficiency

Deficiencies in temperature and pressure profile requirements were identified in those cases where a significantly nonconservative difference between the test conditions and the required accident conditions was noted. Examples of typical deficiencies are identified as follows:

1. Plant accident environment conditions were identified as having elevated pressure and temperature for periods up to 24 hours, whereas testing for only 1 or 2 hours was provided as evidence of qualification.

2. LOCA testing temperatures in the vicinity of 300°F were used as evidence of qualification for main steam line breaks having temperatures in the range of 360°F without analysis to establish that the existing tests provide assurance of qualification.

3. Pressure effects were sometimes analyzed separately with the statement that the component was not susceptible to failure by pressure and therefore pressure tests need not be performed. The effects of pressure combined with high humidity and contaminants were not evaluated.

4. Elevated temperature testing in an air oven at atmospheric pressure without the presence of steam at elevated pressure was used as evidence of qualification for LOCA and MSLB without supporting analysis.

5. Use of "design rating" supplied by manufacturers for pressure and temperature qualification without any test or analytical information to support such claims was given as proof of qualification.

4.6.3 Resolution

With the exception of those cases where technically justifiable extrapolation of valid test data would envelop the required test profiles, the simplest resolution for equipment having temperature and pressure profile deficiencies is to qualify it by test or to replace it with equipment qualified for the environment to which it would be exposed. (Refer to the discussion of the deficiency of steam exposure, Section 4.9, for the applicability of analysis to equipment subject to steam and elevated pressure and temperature.)

4.7 DURATION ADEQUACY (OPERATING TIME, OPERABILITY PERIOD)

4.7.1 Requirements

NUREG-0588 Categories I and II, Section 2.2(4), 3(4)
DOR Guidelines, Section 5.2(1)

The regulatory requirements identified in the DOR Guidelines and NUREG-0578 mandate that where qualification testing is employed, the test

profile (i.e., elevated temperature and pressure with description of steam and humidity conditions) should be of sufficient duration as to envelope the plant-specific accident conditions. The duration should be equal to or exceed the period starting with initiation of the harsh environment and ending when the parameters return to their normal values or the safety function of the equipment is no longer required. (Refer to Sections 3.8, 4.17, and 4.18 for discussion relating to margin.)

4.7.2 Description of Deficiency

This deficiency was noted in qualification programs that cited a test of insufficient duration when compared to plant-specific criteria. Many plants have equipment with post-accident functional requirements of a year or more. Most LOCA tests have had a duration of 30 days or less. Some recent testing has been extended to 180 days.

4.7.3 Resolution

When the duration of the LOCA test is insufficient for the intended application, the use of analysis combined with conservative engineering judgment may allow extrapolation of the results; however, complete resolution of the deficiency may not be possible without retesting.

4.8 ENVELOPING OF PROFILE

4.8.1 Requirements

NUREG-0588, Categories I and II, Section 2.2(4)
DOR Guidelines, Section 5.2.1

The regulations identified require the test profile to envelope the postulated accident profile for the installed location when qualification by testing is employed.

4.8.2 Description of Deficiency

Failure to envelope the postulated accident was not often a finding during the review. Generally, more significant shortcomings were noted with

the qualification documentation such as lack of testing to a steam environment, making the finding of lack of enveloping unnecessary.

4.8.3 Resolution

For those equipment items for which more significant deficiencies were identified, the more significant finding would have to be resolved. Proper resolution of that finding would resolve the enveloping question.

For those cases where enveloping was not adequate and was a finding, possible resolution could be extrapolation of test data with technical supporting rationale, reduction of accident conditions through reanalysis, retesting, relocation, or shielding.

4.9 STEAM EXPOSURE

4.9.1 Requirements

DOR Guidelines, Section 5.1
NUREG-0588, Sections 1.1 and 1.2

4.9.2 Description of Deficiency

Two basic types of steam exposure deficiencies were noted during the review.

1. The item was not tested in a steam environment although the equipment could be subject to a steam environment resulting from a LOCA or HELB. The problem was not usually associated with equipment located inside containment and purchased since 1974. The problem is most commonly associated with safety-related equipment located in HELB areas outside containment. For such equipment, some licensees attempted to substitute thermal and pressure analyses, applicable vendor product bulletins on temperature ratings, dry air oven aging of and testing of materials and subcomponents, and unsubstantiated in-plant operating experience. These data and analyses usually did not provide adequate assurance of qualification.

2. In a very few instances, instruments were subjected to high-temperature dry air tests or contact with hot aluminum blocks and then subsequently subjected to a gas pressure to qualify them for use in containment. These tests are not considered adequate proof of capability to withstand a steam environment.

4.9.3 Resolution

In general, only qualification testing with steam conditions or replacement with fully qualified devices would resolve this deficiency.

4.10 CHEMICAL SPRAY

4.10.1 Requirements

DOR Guidelines, Sections 4.4.1.4, 4.4.2.4, and 4.4.3.2.4
NUREG-0588, Section 1.3 and Resolution 61

4.10.2 Description of Deficiency

1. Frequently when materials analyses were performed on equipment to establish qualification for chemical spray exposure, the evaluation did not consider the increase in reactivity of the spray solution with increase in temperature or the effects of solid chemical deposition on equipment internals, e.g., plateout of salts on terminal blocks internal to motorized valve actuators.

2. Analyses using data from testing of the same or similar equipment but using different chemical compositions, concentrations, or spray rates did not provide the technical rationale that substantiated the position claimed. Material-dependent differences, i.e., the effect of acidic versus basic solutions on different materials, were not addressed. The arguments used to support the analyses were general in nature and did not provide or reference supplemental test data or analyses.

3. Major differences were also found between the housings and mounting methods of installed equipment and that of the tested equipment; therefore, the adequacy of the device to withstand chemical spray was questionable. Differences in mounting, electrical termination, compartment sealing, cable penetration, and enclosure type were found during the review.

4.10.3 Resolution

The device as it is installed must be shown through test or thorough evaluation of the housing and interfaces to maintain its safety function during and after chemical spray. When a device is made so that chemicals are not prevented from entering, a full qualification test may be the only way to establish that the effects of chemical attack can be withstood.

4.11 SUBMERGENCE

4.11.1 Requirements

DOR Guidelines, Section 3
NUREG-0588, Categories I and II, Section 5

4.11.2 Definition of Deficiency

Deficiencies associated with submergence frequently occurred for the following reasons:

a. Equipment Located Inside Containment

1. The equipment was identified by the licensee as being located below the submergence level that would result from a loss-of-coolant accident, but no test information was provided which would establish the ability of the equipment to function after it became submerged.

2. The equipment is required to function only before submergence, but no failure modes-and-effects analysis was performed to establish that failure after submergence would not mislead an operator or subject other safety-related equipment to failure.

b. Equipment Located Outside Containment

1. The equipment was identified by the licensee as being located below the submergence level which would occur as a result of a high energy line break or other source of flooding. The equipment was identified as being required to function after submergence; however, no qualification documentation was supplied.

2. The equipment is not required to function, but no FMEA or single failure analysis was performed to establish that failure would not result in failure of other necessary equipment.

Frequently, the licensees attempted to establish qualification of equipment which would become submerged by referring to saturated steam testing, ICEA accelerated water absorption testing for cables, or testing in river water. Submergence simulation is particularly problematic for equipment located inside containment, and accounting only for pressure and temperature effects is usually inadequate. The flood water is composed of water that may be borated or contain caustics and other contaminants that have been washed

down from equipment and structural surfaces of the primary containment. A further complication is that the containment spray may cause radioactive contaminants from the containment atmosphere to accumulate in the water flooding the compartment or sump. No estimates of the radiation doses or dose rates were provided by licensees for equipment which would be submerged.

4.11.3 Resolution

As noted by both the DOR Guidelines and NUREG-0588, the best method of eliminating the problem of submergence simulation is to locate the equipment above the submergence level. If the equipment cannot be relocated above the submergence level, then encapsulation or isolation from submergence may be the best alternative, and it would frequently allow use of existing test results. Encapsulation would require sealed enclosures made to withstand elevated pressure and temperature. The equipment would have to be qualified for temperature and radiation in the aged condition, and the encapsulation would have to be tested for integrity and pressure capability. Periodic testing of the enclosure to ensure that the integrity is maintained would be required to maintain qualification of the encapsulated device. An alternative would be inclusion of submergence testing under the anticipated conditions as part of a full qualification program.

4.12 RADIATION

4.12.1 Requirements

DOR Guidelines, Sections 4.1(2), 5.2(3)

NUREG-0588 requires IEEE Std 323-1971 or 1974 radiation qualification requirements to be followed.

4.12.2 Description of Deficiency

The radiation-related deficiencies that were encountered are:

1. The most serious radiation-related deficiency noted during the review was material failure as a result of radiation exposure. This problem occurred in equipment employing Teflon, some rubber compounds, some

lubricants (both oils and greases), and some sensitive electronic components of instrumentation.

2. In some cases, no test or analysis for radiation withstand capability was provided when LOCA radiation conditions were postulated.

3. A deficiency was cited when the integrated dose of reported test results was lower than the radiation dose requirement. This problem was usually encountered on equipment which was originally qualified to requirements based on source terms lower than now required.

4. Some instruments and control devices were found to be sensitive to radiation. Typical results have been reduction in accuracy or shift in setpoint on transmitters and switches. These effects may be caused by radiation dose, dose rate, or both. It was frequently not possible to determine from the documentation if an instrument that is sensitive to radiation exposure would perform adequately or inadequately under actual DBE conditions.

5. Many material analyses used radiation damage data most favorable to attaining qualification rather than applicable conservative data. This problem was encountered for equipment located both inside and outside containment. Radiation damage data for elastomers and other organic materials show considerable scatter. Many handbooks provide radiation damage data for plastics, elastomers, and other organic materials which are useful in scoping and selecting materials for design. However, the use of such references for qualification is generally insufficient. It is preferable to obtain data for the actual materials used in the device on properties which would affect the functioning of the device. Manufacturers, when they are aware that material will be subject to irradiation, have been known to add compounds to organic materials that reduce damage from irradiation without modifying the generic descriptions. Therefore, extreme care must be taken when evaluating test results or the capabilities of organic materials without consulting the manufacturer to verify actual material composition.

6. A common problem encountered with equipment located outside of containment and subject to radiation from recirculating fluids was the use of data for elastomeric materials, such as gaskets and O-rings, which was improper for the application. Data for tensile properties were generally used to evaluate the performance of gaskets and seals. The correct approach would be to analyze the behavior of the material under compression. It should be noted that the tensile properties are usually less affected by radiation than the compressive properties.

4.12.3 Resolution

1. Equipment or Component Failure Under Radiation Exposure

   Equipment in this category should either be replaced with fully qualified equipment or used only in locations where there is no possibility of significant radiation exposure.

2. No Radiation Test Documentation Provided

   For equipment for which radiation testing documentation is available and a complete list of materials is available, an analysis may be possible to establish qualification. If, however, a review of the list reveals materials or components which may be sensitive to radiation, then a test should be performed. If analysis is performed, the cumulative effect of radiation degradation and other forms of degradation from aging and accident conditions should be evaluated.

3. Results of Test or Analysis Are Lower Than Current Plant Requirements

   This deficiency may be resolved by analysis or test. If a detailed materials list is available, the effect of radiation on the materials may be evaluated and the equipment qualified by analysis. As an alternative, the required dose could be reevaluated for the exact location of the equipment. If plant design permits, the equipment could be relocated or shielded. Lastly, if there are insufficient data and other alternatives cannot be performed, a separate radiation effects test at the required dose rate could be performed to determine whether the item can be affected by the required dosage. If it is affected substantially, then the resolution would be to replace the item with qualified equipment or perform a full qualification test. If the radiation effects are shown to be negligible, the separate effects test would be considered suitable for qualification under the DOR Guidelines. However, NUREG-0588, Section 1.48 also requires that possible deleterious effects on component performance due to beta radiation heating and ionization be addressed. Since radiation exposure tests are relatively inexpensive, such testing may be the most cost-beneficial approach for determining the appropriate method of resolution of the deficiency.

4. Separate Effects Testing in Which Radiation Has Been Shown to Degrade the Equipment

   In this case, the equipment has been demonstrated by testing to be susceptible to radiation. Some corrective actions are to shield the equipment to eliminate the radiation dose, to relocate the equipment out of a radiation area, to perform full qualification tests, or to replace the equipment.

5. Problems Associated With Selection of Data for Use in Analysis

An acceptable basis for establishing performance under irradiation is data on the exact material used in a like application, for example, neoprene O-ring test data used in an analysis of neoprene O-rings. Data for items analyzed for compressive loads should be from tests under similar or equivalent loadings. It is recognized that in many cases it is not possible to obtain such data on every material; however, the properties available for generic materials or for the primary ingredient of a material may be significantly different from the properties of the specific material being considered. Care should be exercised to select data related to the material property of interest. Radiation damage thresholds are significantly different for such properties as compressive strength, tensile strength, and dielectric strength.

4.13 TEST SEQUENCE AND SEPARATE EFFECTS TESTING

4.13.1 Test Sequence

4.13.1.1 Requirements

DOR Guidelines, Section 5.2.5
NUREG-0588, Section 2.3

4.13.1.2 Description of Deficiency

Test sequence deficiencies generally were given when the test was not performed in the sequence required by the referenced sections of the DOR Guidelines, NUREG-0588 and when inadequate justification for the difference in sequence was provided. Deficiencies concerning test sequence were identified on the following three bases:

- o Equipment containing materials subject to aging degradation was not aged, or aging was performed on samples separate from those LOCA tested.
- o Equipment containing materials subject to degradation by irradiation was not irradiated prior to LOCA testing; irradiation was conducted on separate samples; or analyses, which proved to be inadequate, were performed in lieu of irradiation. In a few cases, irradiation was performed after LOCA simulation testing.
- o Information was not available on the performance of organic materials, and separate effects tests were performed for each of thermal aging, radiation, spray, and LOCA. In these cases, if degradation of the

materials was identified during any of the separate tests, then a deficiency regarding test sequence was identified since cumulative degradation might have prevented proper operation of the equipment.

4.13.1.3 Resolution

There are two basic approaches to resolution of this deficiency. The first is to perform a qualification test of a representative sample of the device. The second is to replace the equipment with qualified equipment. Other approaches may be possible; however, these two are the most direct.

4.13.2 Combined Effects Versus Separate Effects

4.13.2.1 Description of Deficiency

Analyses were performed to establish harsh environment qualification by determining the ability of a material to withstand the effects of each environmental parameter independently. No attempt was made to determine the effects of cumulative degradation on the material. Frequently, the material property most important to correct functioning of the device was not stated, or properties of little importance were considered and primary properties were ignored. This deficiency does not include the possibility of synergistic effects.

4.13.3 Resolution

Analyses performed for equipment located in harsh environments should first determine the material properties (e.g., insulating capability, structural strength, tensile strength, compressive strength) that will affect the device's ability to function. These properties should be the basis for the analysis of individual environmental parameter effects. An effort should be made to determine the cumulative effect of the separate environmental effects and a conservative engineering judgment used to determine capability to withstand the cumulative environment.

4.14 TEST FAILURES AND SIGNIFICANT NONCONFORMANCES

4.14.1 Requirements

DOR Guidelines, Section 5.2(5)
NUREG-0588, Section 2.2

Resolution 60 of Comments on NUREG-0588 states:

"Resolution 60 - (2.2(9))

The intent of Section 2.2(9) is to ensure that intermittent failures in equipment--such as momentary change of state of bistables (that is, contact chatter), a cyclic variation in a transmitter output or a valve position variation--have been accounted for in the qualification testing program. Where intermittent failures in equipment can negate a safety function, the test program should include provisions to monitor selected parameters on a continuous basis in order to detect these failures (if any). It is recognized that certain equipment requires long-term testing (for example, postaccident monitoring equipment) where around the clock monitoring is difficult to accomplish. For this category of equipment, continuous monitoring for spurious or intermittent operation during periodic intervals may be justified."

IE Bulletin 79-01B Supplement 2 states:

"When a failure occurs due to a non-EQ related mechanism, acceptability of analysis to extrapolate the test data would be dependent on several considerations (e.g., the specific function being demonstrated, the failure mechanism, when the failure occurred, etc.), and may be very difficult to achieve. If such a failure occurs it may be more prudent to correct the failure and continue with the test."

4.14.2 Description of Deficiency

Test failures and significant anomalies occurred in some qualification programs; these were associated with failure of test facilities or the equipment being tested. An example of test facilities failure is the case where the LOCA chamber temperature and pressure peaked at 360°F and 70 psi rather than the specified 320°F and 50 psi, resulting in failure of the test sample to remain within the specified accuracy.

Some other examples of equipment failures and significant anomalies during testing are:

1. An electronic transmitter was tested using the IEEE Std 323-1974 profile for a PWR and failed within the first half-hour of the test.

2. During a 30-day test of a motorized valve actuator using the PWR and BWR profiles of IEEE Std 323-1974, the actuator functioned normally through the peak pressure and temperature transients during the first 24 hours, continued to function normally up to 15 days, and then failed.

3. A solenoid operated valve was tested for 30 days, using the profile contained in IEEE Std 323-1974; however, the sealing method precluding entry of spray and steam into the solenoid enclosure failed, with the net result that boric acid spray entered the solenoid enclosure. The valve continued to function normally but did not withstand insulation resistance testing. This is a significant anomaly.

Probably the most common anomaly encountered in the review of environmental qualification was connected with instrument accuracy or automatic device setpoints. Many of the older test programs did not have preestablished acceptance criteria, and data were reported as recorded by the test instrumentation. In older test reports, it is not uncommon to find variations in instrument accuracy of 10% to 40%, and to find variations in setpoints of certain automatic devices of 5% to 20%. These changes indicate anomalous behavior which must be evaluated with respect to the application.

4.14.3 Resolution

The licensee should recognize that for many of the older tests, preaging of the equipment was not performed and that anomalous behavior may become exaggerated as equipment grows older, thus making engineering judgments questionable concerning devices showing significant abnormalities in accuracy or setpoint. In these cases, it would not be technically sound to extrapolate the adequacy of the device over any extended lifetime. In general, it would be preferable to replace such devices with fully qualified equipment.

4.15 FUNCTIONAL TESTING

4.15.1 Requirements

DOR Guidelines, Section 5.2.5
NUREG-0588, Sections 2.1 and 2.2

4.15.2 Description of Deficiency

Deficiencies concerning functional testing requirements were infrequently noted during the review. However, when such a deficiency was identified, it was normally associated with one of the following problems:

- o The device was subject to LOCA testing but not energized during the test and no performance data were taken. This deficiency was associated with a few cables and indicating switches.
- o A functional testing deficiency associated with temperature detectors, thermocouples, and similar devices was LOCA testing without monitoring. Thus, while the device was subject to a simulated accident environment, it was impossible to determine whether the device would function accurately in such an environment.
- o In some cases, devices subject to possible malfunction during irradiation were found to have been irradiated without being energized or without being monitored for correct operation during accident simulation irradiation. This problem was found in some instrumentation and in some instrumentation cable test reports.

In general, deficiencies associated with functional testing were identified only in those instances where environmental qualification testing was performed, but no data were taken or submitted to establish that the equipment item would perform its function under the accident condition.

4.15.3 Resolution

The best resolution to this deficiency is to prove functional capability under accident conditions. This can be done by (1) performing complete verification tests or (2) replacement with a qualified device which has proof of functional capability under accident conditions. Other methods may be possible; however, these are the most direct.

4.16 INSTRUMENT ACCURACY

4.16.1 Requirements

DOR Guidelines, Section 5.2.5
NUREG-0588, Sections 2.1 and 2.2

4.16.2 Description of Deficiency

Deficiencies concerning instrument accuracy were of two kinds:

- o Instrumentation was tested, but no data on accuracy or on drift of setpoint and zeropoint were provided in the test report.
- o Data on drift, accuracy, or other parameters concerning instrument performance were provided in the test report, but the significance of the numbers was not evaluated for acceptability for the licensee's application.

4.16.3 Resolution

When no data are available on instrument accuracy, two basic options may be pursued. The first is to perform a retest on a representative sample. The second is replacement with qualified devices for which information on accident period accuracy is acceptable. For the second deficiency described above, the data provided should be evaluated to establish that in each application of the instrumentation, the error, drift, changes in setpoint, etc., are acceptable and do not compromise system functions or the reliability of information provided to the operator.

4.17 TEST DURATION MARGIN

4.17.1 Requirements

DOR Guidelines, Section 6 (Margin)
NUREG-0588, Rev. 1, Category I, Section 3(4)
NUREG-0588, Rev. 1, Category II, Section 3(4)
IEEE Std 323-1974, Section 6.3.1.5
Comment 76 of NUREG-0588, Rev. 1

"Resolution

For equipment subjected to hostile environments resulting from pipe breaks, an accepted practice is to qualify that equipment to the most limiting environment (which would envelope the less hostile environments caused by a range of different pipe breaks). Subjecting the equipment to the most severe portion of the hostile environment (maximum pressure, temperature, and radiation) for only a very short time period (seconds or minutes) does not provide adequate assurance that all the environmental service conditions have indeed been enveloped. It is the staff's belief that the additional one hour of

demonstrated functional operability for equipment required to operate for only a short period (that is, less than or equal to 10 hours), provides for the most part, the assurance that the equipment will function in any accident environment that can exist during large and small line-break accident scenarios.

There may be some designs where less restrictive margins may be justified and found acceptable on a case-by-case basis (see Category II, *Section 3(2)). The staff believes, however, that the general* requirement of testing for an additional hour is warranted."

4.17.2 Description of Deficiency

This deficiency resulted when testing did not demonstrate the equipment item's functional capacity for one hour beyond the required operating time and the operating time was 10 hours or less. The requirement has been referred to as the 1-hour minimum margin. The basis for the requirement was provided by the staff in response to Comment 76 of NUREG-0588, Rev. 1, as stated above in Section 4.17.1.

The last paragraph of the resolution quoted in Section 4.17.1 permits the use of less restrictive time durations on a case-by-case basis if sufficient justification for the specified operating time was provided. This justification must include, for each application of each piece of equipment, (1) consideration of a spectrum of breaks, (2) the potential need for this equipment later in an event or during recovery operations, (3) a determination that failure of the equipment after the maximum operability time will not degrade any safety function or mislead the operator, and (4) a determination that the margin applied to the minimum operability time, when combined with the other test margins, will account for the uncertainties associated with the use of analytical techniques in the derivation of environmental parameters, the number of units tested, production tolerances, and test equipment accuracies. The documentation must also include an analysis showing that the failure could not occur during the required period of operability plus the required interval of margin. In most cases, however, where specified operating times of less than one hour were used, inadequate or no justification was provided.

A problem that has arisen with respect to this requirement has been the claim that a device is qualified for its intended application because its specified operating time is on the order of one minute when the device failed after several minutes into the testing. The DOR Guidelines are very explicit with respect to such test failures. Section 5.5 states (in part),

> "If a component fails at any time during the test, even in a so called 'fail-safe' mode, the test should be considered inconclusive with regard to demonstrating the ability of the component to function for the entire period prior to the failure." (For more information on test failures, see Section 3.3.3 of this document.)

4.17.3 Resolution

The methods of resolving failure to meet the 1-hour minimum margin requirement depend on the nature of existing test results. For devices that failed very early in the accident simulation, replacement with qualified devices seems the most prudent method. Relocation, environmental conditioning of the location, or shielding could also be considered. For items that were tested for short durations only, retesting for longer durations may be appropriate.

4.18 MARGIN (General Application)

4.18.1 Requirements

DOR Guidelines, Section 6
NUREG-0588, Rev. 1, Cat. I, Section 3
NUREG-0588, Rev. 1, Cat. II, Section 3
IEEE Std 323-1974, Section 6.3.1.5

4.18.2 Description of Deficiency

This deficiency is most directly associated with equipment items which must be qualified to the requirements of NUREG-0588. The majority of the plants reviewed were qualified and reviewed to DOR Guidelines and the margin issue was overshadowed by more fundamental concerns. A discussion of margin problems for DOR plants would therefore be inappropriate. The topic of margin is treated in depth in Section 3.8 of this document.

5. DISCUSSION OF QUALIFICATION REVIEW FINDINGS

This section is divided into two parts. The first part concerns equipment for which qualification has not been established or found to be only partially qualified and which requires a significant effort for resolution of the qualification concern. These devices are:

Containment Penetrations Using Organic Sealing Compounds Rather than Ceramic Sealants (5.1.1)*

Transmitters with Poorly Sealed Electronics Cavities (5.1.2)

Cable--Power, Control, and Instrument (5.1.3)

Large Motors (5.1.4)

Interface Components (5.1.5)

The second part of the section deals with problems of a more easily solved nature. These involve:

Terminal Blocks (5.2.1)

Motorized Valve Actuators (5.2.2)

Solenoid Valves (5.2.3)

Lubricants (5.2.4)

General Equipment Problems (5.2.5) — No section 5.25 in report

Table 5-1 summarizes the results of the EEQ review performed by FRC. It should be noted that more than 69% of the items fall into two categories, "Equipment Qualification Pending Modification" and "Equipment Qualification Not Established," and that only 8% of the equipment was considered fully qualified. This section is concerned primarily with the 37% of the items which were deemed "Equipment Qualification Not Established." This designation does not mean that these items are not qualifiable; it means that further effort is required to establish full qualification. Qualification of these devices may or may not be possible.

*Numbers in parentheses indicate the subsection in which each item is discussed.

Table 5-1

THIS REPORT IS A SUMMARY OF THE NUMBER OF EQUIPMENT ITEMS IN EACH OF THE 8 NRC QUALIFICATION CATEGORIES AS OF MAR 31, 1983 WHICH INCLUDES THE REVIEW OF 71 PLANTS

THE TOTAL NUMBER OF EQUIPMENT ITEMS IN CATEGORY I.A IS (CATEGORY I.A --- EQUIPMENT QUALIFIED)	651	(8.132%)
THE TOTAL NUMBER OF EQUIPMENT ITEMS IN CATEGORY I.B IS (CATEGORY I.B --- EQUIPMENT QUALIFICATION PENDING MODIFICATION)	2588	(32.330%)
THE TOTAL NUMBER OF EQUIPMENT ITEMS IN CATEGORY II.A IS (CATEGORY II.A --- EQUIPMENT QUALIFICATION NOT ESTABLISHED)	2977	(37.189%)
THE TOTAL NUMBER OF EQUIPMENT ITEMS IN CATEGORY II.B IS (CATEGORY II.B --- EQUIPMENT NOT QUALIFIED)	99	(1.237%)
THE TOTAL NUMBER OF EQUIPMENT ITEMS IN CATEGORY II.C IS (CATEGORY II.C --- EQUIPMENT SATISFIES ALL REQUIREMENTS EXCEPT QUALIFIED LIFE OR REPLACEMENT SCHEDULE JUSTIFIED)	900	(11.243%)
THE TOTAL NUMBER OF EQUIPMENT ITEMS IN CATEGORY III.A IS (CATEGORY III.A --- EQUPIMENT EXEMPT FROM QUALIFICATION)	254	(3.173%)
THE TOTAL NUMBER OF EQUIPMENT ITEMS IN CATEGORY III.B IS (CATEGORY III.B --- EQUPIMENT NOT IN THE SCOPE OF THE REVIEW)	381	(4.760%)
THE TOTAL NUMBER OF EQUIPMENT ITEMS IN CATEGORY IV IS (CATEGORY IV --- DOCUMENTATION NOT MADE AVAILABLE)	155	(1.936%)
THE TOTAL NUMBER OF EQUIPMENT ITEMS REVIEWED TO DATE IS	8005	

5.1 DEFICIENCIES REQUIRING SIGNIFICANT EFFORT FOR RESOLUTION

5.1.1 Electrical Penetration Qualification Assessment

The purpose of electrical penetrations in nuclear power plants is twofold:

1. to permit transfer of electrical power and signals through the containment wall

2. to ensure containment pressure boundary integrity under normal and accident conditions.

Electrical penetrations are designed for a wide range of applications including circuits for co-axial and tri-axial instruments, low-voltage instruments and thermocouples, low-voltage power and control functions, and medium-voltage power.

The level of qualification of many canister and modular penetrations using epoxy compounds as the pressure boundry seal is difficult to determine. Of all the reports reviewed concerning these designs, it has not been possible to assemble a set of documents which would satisfy the requirements of DOR Guidelines, NUREG-0588, or IEEE Std 317-1976.

The types of deficiencies found for penetrations having a pressure boundary seal of epoxy material were:

- o LOCA testing did not include chemical spray, and analyses did not address critical materials.

- o Radiation evaluation was by analysis and individual material tests; no irradiation of the LOCA test specimen was performed.

- o Penetrations were not aged and aging evaluation was conducted for proprietary epoxy components but not for all degradable material.

- o Test documentation shows substantial reduction in insulation resistance (greater than 4 decades) during steam exposure. Analysis of the significance of the reduction in insulation resistance was not in the documentation submitted for review.

- o Data on continuous, short-time overload and short-circuit current testing (if performed) have generally not been provided by any licensee. In the one case when the test documentation was available, it was not possible to determine whether the same penetration sample was subjected to other accident tests.

Although seismic considerations were not a part of the review associated with this Implementation Guide, some of these penetrations were found to have had seismic tests performed in samples other than those tested for other environmental conditions.

Because of the tendency of some epoxy and other organic materials to shrink with age and to absorb water when subjected to LOCA conditions after irradiation, the lack of aging and irradiation of the test module makes the qualification of the canister and modular penetrations using epoxy sealing materials questionable. Material tests for penetration subcomponents (radiation and aging) were concerned with mechanical properties and not necessarily with the behavior of the material when it is performing its function in the penetration. In addition, the heating caused by short-circuit current during LOCA simulation may exceed the withstand capability of the potting compounds and epoxy used in the penetrations.

Based upon the limited tests conducted and the manner in which the testing was performed, it cannot be established that these penetrations are qualified and that they will perform satisfactorily in accident conditions with regard to mechanical integrity and electrical performance. Therefore, consideration should be given to testing representative samples of the subject penetration types following the recommendations of IEEE Standard 317.

5.1.2 Electronic Transmitters

The major qualification concern associated with electronic transmitters is that the electronic internals of the transmitters are not suitable for exposure to steam. To date, whenever steam entered the electronics cavity during testing, a transmitter failure occurred. These failures varied in nature from large inaccuracies to cessation of operation. The deficiency is further complicated because the mode of failure caused by exposure to steam is not predictable; that is, any individual transmitter may read high, may read low, or may not read at all under accident conditions, so that a reliable failure modes-and-effects analysis is not possible.

In most electronic transmitters that have been supplied for the nuclear industry, steam can come in contact with the electronic parts by entering the transmitter case through the cover gasket or O-ring seal, or through the conduit threads for the electrical connections.

5.1.2.1 Transmitter Cover Seals

In most of the electronic transmitters in use, i.e., produced prior to 1982, elastomers were used for the cover seal. These elastomers were highly compressed to be able to withstand the required environmental pressure and temperature. (If these seals were for mechanical equipment that would be exposed to similar pressures and temperatures, elastomeric materials would not have been used. ASME Code and ANSI Standards would be applied and other types of seals would have been used.) While test data for evaluating aging of most elastomeric materials in highly compressed applications does not presently exist, operating experience and test data on various units by manufacturers indicate rather rapid age degradation of highly compressed elastomeric seals. As the seals degrade, the ability of the elastomer to provide sufficient force against the cover and body to prevent steam entry decreases. Thus, after a few years, it would be possible for steam to enter the transmitter case during an accident, come in contact with the electronics, and thereby cause the transmitter to fail. Accordingly, installed transmitters should have their cover gaskets or O-ring seals replaced periodically, preferably at intervals corresponding to the length of the refueling cycle, until qualified transmitters or transmitter seals with longer demonstrated lifetimes can be obtained.

5.1.2.2 Transmitter Conduit Connections

Some transmitter designs have fused ceramic or fused glass seals as part of the conduit connections, thereby providing a pressure- and temperature-proof seal which would preclude steam from entering the electronic portions of the transmitters through the conduit connection. Other units depend on proper sealing of the conduit threads and the conduit system. Various sealing

methods could be used; for example, Teflon tape as a thread seal was demonstrated in qualification of various limit switches, and room temperature vulcanizing silicone rubber (GE Company RTV), as a conduit thread sealant has been qualified in test reports for various utilities. Other sealing methods appropriate to the installation could be qualified without requalification of the associated devices. Verification of suitable thread sealing and conduit cable entrance sealing should be made to ensure that steam resulting from accidents would not enter the internals of the electronic transmitters. The conduit system must also be sealed. For example, junction boxes in the conduit system may have drainage holes which could allow steam and moisture to enter the conduit and migrate into the transmitter, causing failure.

5.1.3 Qualification Evaluation of Electric Cable

Of all the electrical equipment identified in the environmental qualification program, the most extensively tested has been electrical cable. One major problem identified was that the licensee had not established that the cable installed in the plant is sufficient similar to the cable of the test report. This problem generally can be resolved by more fully identifying cable characteristics so that it is evident that the cable tested and the cable installed are equivalent. The characteristics needed to establish such similarity are contained in IEEE Std 386-1976. As an alternative, the licensees could obtain certification from the manufacturer that the cable furnished for installation is equivalent to the cable tested in the manufacturer's report.

Another important problem with cable qualification documentation is that the cable functional tests and monitoring generally did not include those parameters important to many applications. A typical example is the case of shielded instrument cable; during the testing of many of these cables, the only characteristic measured was insulation resistance during accident simulation and high potential testing after accident simulation. The same cable, when used in conjunction with the device requiring such cable, showed inadequate performance. A change in the impedance of the cable was such that

the required signal could not be transmitted. This example underscores the importance of the recommendations by IEEE Standard 383 which state that the characteristics of interest in the application of the cable should be measured and evaluated during the accident simulation.

Many test reports indicate substantial reduction in insulation resistance during LOCA simulation. In many cases, insulation resistance was essentially zero when measured at a dc potential of 500 V. To determine an insulation resistance during the test, low voltage meters were employed to prevent insulation breakdown. The significance of substantial reductions in measured properties such as insulation resistance was not evaluated in the licensee qualification submittals. Manufacturers and test laboratories generally do not know the end use of the cable and, therefore, do not measure or evaluate the properties of importance to the plant applications. Significant changes in any characteristic of electrical cable need to be evaluated by the licensee to establish that the qualification levels are adequate. Since the ultimate purpose of qualification is to ensure that the equipment subjected to accident conditions will perform its function during accident conditions, the evaluation of data obtained during cable testing should be performed to assure proper system operation.

Submergence simulation is particularly problematic, especially for inside containment applications. While pressure and temperature may be known, the liquid is composed of water that is borated in PWR plants and contains caustics and other contaminants that have been washed down from equipment and structural surfaces of the reactor building. To be conservative, it should be assumed that the containment spray is effective in removing radioactive nuclides from the drywell atmosphere which then accumulate in the water flooding the compartment or sump. Conservative estimates of the radiation doses and dose rates must be determined for cables and splices which would be submerged.

The best method of eliminating the problem of submergence simulation is to locate the cable above the submergence level if practicable. If the cable cannot be relocated above the submergence level, then encapsulation or

isolation from submergence may be the best alternative; this may allow use of the existing test results. The encapsulation method and materials will require qualification testing to elevated pressure, temperature, radiation, and worst-case chemical conditions. The encapsulation system would have to be aged prior to LOCA/HELB and submergence testing. If neither relocation nor encapsulation is practical, an alternative is submergence testing of cables and splices as part of a full qualification program. The testing of instrument cables should include measurements of the characteristics which would affect signal transmission.

5.1.4 Large Electric Motors

Electric motors are used in many applications in nuclear power plants, and qualification concerns vary with the application. This discussion is limited to problems associated with ECCS system motors and only those ECCS motors needed for long-term operation. Demanding requirements are imposed upon motors used in ECCS and long-term cooling functions. These motors are used as drivers for pumps and various types of fans, which are located both inside and outside containment and above or below submergence level.

5.1.4.1 Outside Containment Motors

Motors in this category include applications such as driving auxiliary feed pumps, decay heat removal pumps, high pressure injection pumps, containment spray pumps, and certain vital room air conditioning units. For the outside containment application, the qualification task involves establishing long-term reliability of operation of motor internal parts and of the bearings with their associated lubricants. The environments usually include high humidity, elevated temperature, and radiation caused by the recirculation of radioactive fluids from the containment. Existing qualification documentation has generally addressed the capabilities of the parts of the motor separately and has frequently addressed the environmental parameters separately. For example, motorette aging and radiation tests are extensively cited to qualify motor stator windings without establishing that the motorette and the

materials used in the motorette adequately represent all the materials used in the electrical portion of the motor. Radiation effects on lubricants usually involve tests on the lubricant itself and subsequent evaluations of the lubricant rather than irradiation of the lubricant at the temperatures and loadings that would be encountered in the bearings as installed in the motors. Extrapolation of raw data for lubricants does not assure that the bearings as loaded and irradiated in the motor during accident operation will continue to function for long durations (refer to Section 5.2.4). The materials and their configurations in the tested motors must be shown to be pertinent and applicable to the installed motors. Likewise, during aging and irradiation tests, lubricant and bearing loadings at operating temperatures must be representative of the installed motor conditions.

5.1.4.2 Inside Containment Motors

For those motors used inside containment and above the submergence level, some useful testing has been performed, notably on vertical induction motors, vaneaxial fan motors, and fan cooler motors. In most of these cases, the testing was performed for inside containment environmental conditions and actual motors were subjected to LOCA testing. However, few motors were operated under the loads that would be anticipated in actual in-containment service. A common problem associated with the tested motors is that it is difficult to establish that installed motors for in-containment application are equivalent to the motors tested. Over the years since the testing occurred, motor manufacturing methods and standards have changed, resulting in lighter frames, different insulating systems, and different winding support systems to reduce costs and also allow operation at higher voltages. Because of all these changes, successful similarity analyses may not be possible for some motors. In the review of environmental qualification submitted by licensees, few if any satisfactory similarity analyses for large motors were identified. It appears that a significant effort will be necessary to establish that the existing test documentation for inside containment applications can be extrapolated to the motors in use.

For those below submergence levels, no submergence testing has been performed. Although some motors used below submergence levels have been tested for LOCA steam environments, the test results indicate that spray and other materials will enter certain portions of the motor and, should the motor be submerged, sump liquids would fill the motor and possibly preclude its operation. At the present time, it is not possible to predict whether any installed motor located below submergence level, and required to operate after submergence, would continue to be operable unless it is protected from submergence by a suitable enclosure which prevents fluid coming in contact with critical parts, including the bearings.

5.1.5 Interface Components

Components used at interfaces between devices are the most frequently ignored qualification items. For the purposes of this document, interface components are those devices that permit electrical, pneumatic, hydraulic, or mechanical signals; power; or process parameters to enter a piece of equipment through its housing. These interfaces frequently provide a physical means of isolating the equipment's internals from harsh environments and DBE conditions. Since interfaces connect the device to surrounding structures and equipment, additional physical stresses may be added to the device's housing by the interface. The DOR Guidelines state:

> "6. Installation Interfaces - The equipment mounting and electrical or mechanical seals used during the type test should be representative of the actual installation for the test to be considered conclusive. The equipment qualification program should include an as-built inspection in the field to verify that equipment was installed as it was tested. Particular emphasis should be placed on common problems such as protective enclosures installed upside down with drain holes at the top and penetrations in equipment housings for electrical connections being left unsealed or susceptible to moisture incursion through stranded conductors."

Some of the common interfaces are splices, terminal blocks, wire terminations such as lugs and butt connectors, conduit connections and pipe threads, and feedthrough assemblies at equipment housings. Thread sealants and O-rings also are part of interfaces.

Many qualification reports ignore interfaces. Many others indicate problems with interfaces during testing. Some of these problems are presented below.

Example of Interface Deficiencies

1. Motor Lead Splices

   - Materials are often not identified or included in the qualification analysis or testing.

   - When analyzed for thermal aging, motor temperature rise was not considered.

   - When manufacturer and vendor were not responsible for the splicing system, the licensee did not evaluate the adequacy of the splicing method.

   Resolution of these concerns can be obtained from an evaluation of the system used. Materials can be evaluated based on tests of splicing methods used.

2. Solenoid Valves and Limit Switches

   During many tests of limit switches and solenoid valves, the conduit for the electrical leads was inappropriately piped through the LOCA chamber so that the internals of these devices were exposed to the ambient conditions external to the test chamber and were not representative of the actual installation in the power plant.

   Evaluation and/or testing of the actual method of connection of these devices is necessary to complete environmental qualification.

3. Housing Cutouts for Electrical Leads of Motor Operated Valve Actuators

   Tests have shown that chemical spray can leak into the switch compartments, thereby causing failures. Terminal blocks have been found to be affected by chemicals used in tests, and plastic switches have dissolved. To date, analyses of these problems have not been found to be adequate, and remedial action has not been proven to be effective.

   For motor operators subjected to spray conditions, the seals at the conduit connection must be shown to be adequate to prevent damage to the switch and termination equipment. The seals associated with the gear works are not as critical since the qualifications generally proved that degradation of the seals under accident conditions does not impede proper operation.

4. Interfaces at Equipment Qualified by Similarity

When establishing similarity between the installed equipment and the test specimen, it is imperative that the qualification documentation address any differences in interfaces and their impact on the applicability of the test. A simple statement that the interfaces are "the same" or "similar" is not sufficient. Adequate documentation must be provided to determine whether or not interface similarity has been established or that the differences are not significant enough to affect the results of the testing. In only a very small percentage of all equipment items reviewed were the equipment item interfaces adequately addressed.

5.2 PROBLEMS MORE EASILY RESOLVED

5.2.1 Qualification Evaluation of Terminal Blocks

Terminal blocks made of a variety of phenolics are widely used for various engineering purposes in nuclear power plants, both inside and outside containment. Some terminal blocks are exposed; other terminal blocks are in junction boxes with pressure equalization holes drilled in the bottom of the box. In a few instances, they are located in pressure-tight NEMA enclosures. The terminal block will perform its normal function as long as the barrier between adjacent terminals is maintained and the surface resistance is maintained to preclude current leakage paths across the terminal block surface. Two basic problems associated with some terminal block designs have been identified during the evaluation of qualification information submitted by the licensees. The first involves the integrity of the electric barrier. Most terminal blocks are made of phenolic, which is a brittle material and has an expansion coefficient substantially different from that of the metal enclosure in which is it mounted. Changes in temperature have caused terminal block barrier cracking because of the difference in expansion between the metal support and the phenolic terminal block when the terminal block was rigidly mounted at both ends. Subsequently, electrical tracking occurs through the broken terminal block because of the lack of path resistance. Reduction of surface resistivity and high leakage currents have been identified in some cases where boric acid spray deposits coated surfaces of the terminal blocks by entering the enclosures through the pressure equalization hole and subsequently causing low surface resistance or

low resistance to ground in the terminal block. Sandia Laboratories has also found that dirt, dust, and other contaminants can result in reduced surface resistance.

The resolution to these problems is an engineering problem for each application. To eliminate the thermal expansion problem, terminal blocks should be mounted in a manner that permits support structure expansion without damage to the terminal block. It is known that the mounting stress problem is more severe with the longer 8-, 10-, and 12-point terminal blocks than with the shorter 4-point types.

The resolution of the surface contamination is to ensure that terminal block surfaces are maintained in a clean condition through good power plant housekeeping practices. Location of terminal blocks and junction boxes should include evaluation of the potential for entry of foreign material, including chemical spray during a coolant accident, so that deposition on terminal block surfaces will not occur. Furthermore, good engineering practice would indicate that terminal blocks inside primary containment where they could be exposed to accident environments should be minimized, being used only where frequent physical access to the circuitry for measurement or calibrations is necessary. For outside containment applications, maintaining cleanliness by normal good plant housekeeping programs would suffice to avoid surface contamination. Boxes should generally be located so that they would not be subject to extreme temperature transients, but if accidents could cause temperature transients, the mounting should allow for differential thermal expansion between the junction box and the terminal block itself. One solution to terminal block problems inside containment has been their elimination either through direct wiring or fully insulated splices.

5.2.2 Motorized Valve Actuators

Every nuclear power plant relies on motorized valve actuators (MVAs) to perform various functions. The basic operation of the device is simple. In most cases, even though the MVAs vary significantly in size and structure, the electrical components remain unchanged in the MVA. Because of this, many

manufacturers have attempted to generically qualify their equipment by testing or analyzing a single model and establishing the applicability of the test results to the other models in the product line or "family."

The major problems associated with the environmental qualification of MVAs were as follows:

a. establishing similarity between the installed and tested equipment

b. adequately describing the installed equipment

c. addressing thermal aging and qualified life

d. addressing test failures and their impact on plant safety

e. poor documentation records by the vendor and the licensee.

A further discussion of each problem is provided below:

a. Similarity - Due to the time period over which MVAs were manufactured, shipped, and installed, the materials used in the construction of these MVAs, primarily the organic components, have changed. Because of this, one model with Class B insulation is not necessarily the same as another. Verification of the similarity between an installed MVA and one listed in a qualification program is therefore necessary. The manufacturer's records will, in most cases, establish which of the qualification reports are applicable to each of the installed equipment items. Inspection of the installed equipment is an alternative means of verification.

b. Equipment Description - To adequately describe the installed equipment, the licensee must provide a complete description of the installed equipment item. This identification should include the following:

   - manufacturer
   - model number
   - motor manufacturer
   - class of insulation of motor
   - type of current used in motor
   - motor-brake identification (if applicable)
     - brake manufacturer
     - class of insulation of motor brake
     - type of current used in motor brake
   - identify all organic materials used in the MVA and the insulation systems.

c. Thermal Aging and Qualified Life - Many licensees have claimed a 40-year qualified life based on experience, analysis, or testing. It should be noted that no qualification program for MVAs has incorporated an aging program based on a complete thermal aging analysis. Most accelerated thermal aging has been performed without prior analysis and is not supported with a technical basis. In the generic qualification reports, some thermal aging information is presented. However, it is unclear whether or not the activation energy is applicable only for the motor insulation (i.e., the varnish) or for the entire motor insulation system (i.e., varnish, motor lead insulation, etc.). A materials analysis should be provided on a case-by-case basis for each portion of the device.

d. Addressing Test Failures - There have been test failures in qualification programs which were not adequately addressed in the reports. In many cases, the licensees have cited these reports, but have not provided an analysis of the failure or the resultant impact on their system capabilities. Of particular interest are those failures caused by chemical attack on the Class B insulated MVAs. These test specimens have all exhibited problems at some point during testing. Many licensees have attempted to take credit for the time up until failure; however, this is not in agreement with the DOR Guidelines, Section 5.2.5. Many of these failures may have resulted from in-leakage of chemical solution through the interfaces or test connection.

   Also, the failure of motor-brake assemblies due to radiation exposure has not been addressed by most licensees. Frequently, the licensee did not identify those MVAs with motor-brake assemblies.

e. Documentation - In some cases, licensees have been told by the manufacturer that their records are incomplete and that they are unable to establish the necessary similarity. This situation dictates the need for a complete materials/similarity analysis to ensure that the equipment item is similar to a particular test specimen and/or that a particular test report is applicable.

Other points should be noted with respect to MVAs:

a. Most MVAs are not totally sealed units. Therefore, the qualification of seals and gaskets is not essential. However, proper maintenance practice mandates that these components be replaced periodically according to the manufacturer's recommendations.

b. The lubricants used in these MVAs should be identified and addressed as a component of the MVA. The lubricant, like the seals and gaskets, should be periodically replaced according to the manufacturer's recommendations.

Some licensees have stated that the seals, gaskets, and lubricants used in these MVAs were all qualified for the life of the equipment. This is a misinterpretation of the qualification reports. The reports generally state that the qualification of the entire device does not depend on absolute sealing and the lubricant can withstand some contamination without affecting the operability of the device. However, the fact that these components are not required to be qualified does not exempt the licensee from replacing these components in accordance with manufacturers' specifications. Keeping a device in the "like-new" condition by replacing components that have exceeded their useful life is one way of justifying a longer qualified life for the complete device.

5.2.3 Solenoid Valves

Two general categories of solenoid valves have been encountered during the review involving environmental qualification. The first category includes commercial off-the-shelf solenoids. Some of these solenoids have Class H coil insulation or other special features but were not designed for nuclear plant service; tests demonstrating qualification have not been identified and, in general, tests were not performed. Most licensees have recognized the lack of qualification data and the likelihood that qualification could not be accomplished and have concluded that these valves must be replaced with qualified units.

Several licensees have referenced various analyses indicating failure modes and probabilities of valve functioning as part of qualification submittals. While such documentation is useful in establishing justification for continued operation, it does not establish qualification because all of the elements that must be addressed as demonstration of qualification in accordance with either DOR Guidelines or NUREG-0588 are not included in such analyses. Aging and the effects of steam exposure are rarely, if ever, addressed.

The second category includes valves designed for nuclear plant service and for which qualification testing documentation is available. These valves fall into two basic functional classes.

The first class involves solenoid operated valves which are used as pilot valves for pneumatically or hydraulically operated containment isolation valves. These valves generally are required to function for small break or large break LOCA to isolate containment and they function for a relatively short time, that is, less than 10 minutes of exposure to the environment, and for many applications the exposure would be less than one minute. Qualification testing has established the suitability of many valves to perform this function. It is prudent, however, to ensure that the coil internals are sealed from the accident environment to avoid direct impingement or contact of steam with the coil internals. It is also important to remember that most of these valves are continuously energized; this means that internal coil temperatures and elastomer temperatures are significantly above ambient room temperatures. As a result, aging degradation is a major problem with these units and extrapolation of manufacturer's recommendations for replacement intervals should be done with extreme caution since there are few data to support doubling or trebling the manufacturer's recommended replacement cycles.

The second functional type of solenoid operated valve is valves required to operate long periods after onset of the accident. Such valves include sampling, long-term cooling system valves, and reactor vessel head vents. To assure long-term accident operability of any manufacturer's solenoid used in these applications, the licensee should ensure that steam or spray does not enter the coil enclosure through the conduit threads, the cable ends, or conduit system. There are several acceptable qualified conduit thread sealing methods available.

5.2.4 Lubricants for Long-Term DBE Use

When separate testing or analyses of lubricants has been performed, the adequacy of the qualification is questionable for bearing systems used in equipment that must operate for long periods under DBE and post-DBE conditions.

Cone and penetration indices for lubricants are virtually useless if a specific test of the bearing or an analysis of the bearing with known properties is not performed to prove adequacy of the lubricant.

If a motor is to be tested for harsh environments, the lubricants should be thermal and radiation aged to simulate the normal service conditions and DBE dose. Typical periodic maintenance and inspections that can detect age-related degradation and contamination will generally limit the amount of thermal aging required to no more than that of the service interval.

If sufficient information is available concerning the running parameters of the bearings during DBE exposure, the adequacy of the lubricant may be determined by analysis. Extrapolations of data concerning similar bearing systems for smaller motors with the same lubricant may also be possible when the cost of qualification testing of a large motor becomes prohibitive.

6. REFERENCES

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same report — SPC delete one

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APPENDIX A

TECHNICAL EVALUATION OF LICENSEES' RESPONSES TO SER CONCERNS

A.1 GENERAL

The generic qualification categories and their descriptions developed by the NRC and used in the Technical Evaluation Report (TER) have been reproduced in this appendix for the reader's convenience. These categories were established by the NRC staff to identify deficiencies of equipment items after a review of all documentation submitted for each equipment item. The information submitted was reviewed for conformance to the appropriate NRC criteria. Upon completion of each review, an overall evaluation of the equipment items and a specific conclusion with respect to its qualification were developed. Based on the evaluation, each equipment item was assigned to one of the eight NRC qualification categories presented below. The number of items in each category was tabulated to give an overall indication of the level of the qualification of each power plant.

A.2 NRC QUALIFICATION CATEGORIES AND DEFINITIONS

A.2.1 NRC Category I.a
EQUIPMENT THAT SATISFIES ALL APPLICABLE REQUIREMENTS OF THE DOR GUIDELINES OR NUREG-0588, OR HAS ACCEPTABLE DEVIATIONS FROM THE DOR/NUREG CRITERIA

This category includes equipment items which are fully acceptable on the basis that all applicable criteria defined in the DOR Guidelines or NUREG-0588 are (1) satisfied and the equipment has been found to be qualified or (2) sufficient information has been presented to determine that deviations from the criteria are acceptable or insignificant.

A.2.2 NRC Category I.b
EQUIPMENT FOR WHICH DEVIATIONS FROM THE DOR GUIDELINES OR NUREG-0588 ARE JUDGED CONDITIONALLY ACCEPTABLE PROVIDED THAT SPECIFIC MODIFICATIONS ARE MADE

This category includes equipment items that do not satisfy one or more of the applicable criteria defined in the DOR Guidelines or NUREG-0588; however,

the Licensee has stated that specific modifications will be made on or before a designated date. This equipment is considered by NRC to be conditionally acceptable provided that the specific modifications are made by the Licensee. When the modifications are completed as proposed, the Licensee states that the equipment will satisfy all applicable NRC requirements. Examples of specific modifications are (1) replacement of unqualified equipment with qualified equipment, (2) equipment hardware modification, (3) equipment relocation above submergence level, (4) relocation or shielding of equipment from radiation source, (5) verification of qualification by additional testing, (6) equipment relocation to a mild environment, and (7) qualification testing of equipment in progress.

A.2.3 NRC Category II.a
EQUIPMENT FOR WHICH QUALIFICATION DOCUMENTATION IS INSUFFICIENT TO ESTABLISH THAT THE EQUIPMENT IS OR IS NOT QUALIFIED IN ACCORDANCE WITH THE DOR GUIDELINES OR NUREG-0588

The qualification documentation of equipment items in this category, in accordance with the requirements of the DOR Guidelines or NUREG-0588, is significantly deficient or inconclusive based upon review of (1) the documentation provided by the Licensee or (2) applicable and available qualification documentation associated with the overall equipment environmental qualification program. The qualification documentation indicates significant deficiencies, which can be categorized as follows: (1) appropriate documentation reflecting qualification has not been cited and made available for review by the Licensee and there is no knowledge of applicable documentation; (2) the Licensee is awaiting qualification from the equipment vendor; or (3) the qualification documentation indicates significant deficiencies; however, where testing was conducted, no reported failures or severe anomalies were observed which would unquestionably affect the ability of the equipment to perform its design basis safety function(s).

A.2.4 NRC Category II.b
EQUIPMENT THAT IS UNQUALIFIED

This category includes equipment items whose qualification documentation has been judged to be seriously deficient based upon review of (1) the

documentation provided by the Licensee, or (2) applicable and available qualification documentation associated with the overall equipment environmental qualification program. The qualification documentation indicates serious deficiencies reported during testing; for example, severe anomalies or failure of the test specimen, which could affect the ability of the equipment to perform its safety function. NRC has requested immediate written notification when an equipment item is placed in this category during the course of the review.

A.2.5 NRC Category II.c
EQUIPMENT THAT SATISFIES ALL APPLICABLE REQUIREMENTS OF THE DOR GUIDELINES OR NUREG-0588 WITH THE EXCEPTION OF QUALIFIED LIFE

This category includes equipment items that are acceptable on the basis that all applicable criteria defined in the DOR Guidelines or NUREG-0588 are satisfied with the exception of the qualified life criterion. The Licensee (1) has not evaluated qualified life or replacement schedule, (2) has not adequately evaluated qualified life or replacement schedule, or (3) has not adequately interpreted qualified life in terms of calendar time. [Note: The component replacement schedule discussed in Section 7.0 of the DOR Guidelines is, in effect, a qualified life. It is not essential to use the term "qualified life," but the replacement schedule must be justified.]

A.2.6 NRC Category III.a
EQUIPMENT THAT IS EXEMPT FROM QUALIFICATION

This category includes equipment items that are exempt from qualification on the basis that (1) the equipment does not provide a safety function (i.e., should not have been included in the equipment list submitted by the Licensee), or (2) the specific safety-related function of the equipment can be accomplished by some other designated equipment that is fully qualified and satisfies the single failure criterion. In addition, any failure of the exempt equipment must not mislead the operator or degrade the ability of qualified equipment to perform its required safety-related function.

A.2.7 NRC Category III.b
EQUIPMENT NOT IN THE SCOPE OF THE QUALIFICATION REVIEW

This category includes equipment items addressed by the Licensee in the equipment environmental qualification submittals which are (1) required to achieve and maintain the plant in a cold shutdown condition or (2) located in a mild environment. Supplement 2 of IE Bulletin 79-01B permits deferment of the review of environmental qualification for all safety-related equipment items located in plant areas where the equipment is not exposed to the direct effects of a high energy line break (HELB) or to nuclear radiation emanating from circulation of fluids containing radioactive substances. Supplement 3 of IE Bulletin 79-01B permits deferment of the review of environmental qualification for all equipment required to achieve and maintain the plant in a cold shutdown condition. Supplements 2 and 3 of IE Bulletin 79-01B originally permitted deferment until after February 1, 1981 of the qualification review of equipment located in a mild environment or required to achieve and maintain the plant in a cold shutdown condition. Since the issuance of Supplements 2 and 3, the NRC has determined that the review of environmental qualification for this equipment is not within the scope of this report.

A.2.8 NRC Category IV
EQUIPMENT FOR WHICH QUALIFICATION DOCUMENTATION HAS NOT BEEN MADE AVAILABLE FOR REVIEW

This category includes equipment items for which qualification documentation in accordance with the requirements of the DOR Guidelines or NUREG-0588 has been cited by the Licensee as evidence of qualification; however, this documentation has not been made available for review. Therefore, a conclusion cannot be reached with respect to qualification of this equipment.

APPENDIX B

TABULATION OF REQUIREMENTS COMPARING NUREG-0588, CATEGORIES I AND II TO DOR GUIDELINES AND SUPPLEMENT 2 OF IE BULLETIN 79-01B

This appendix provides a comparison of the requirements contained in NUREG-0588, the DOR Guidelines, Supplement 2 of IE Bulletin 79-01B, and the Resolution of Comments contained in NUREG-0588, Rev. 1. It is provided for convenience to allow rapid review of similar requirements.

COMPARISON OF NRC EQUIPMENT ENVIRONMENTAL QUALIFICATION REQUIREMENTS AND CRITERIA

COMPARISON REFERENCE NUMBER	NUREG-0588, REV. 1 CATEGORY I	NUREG-0588, REV. 1 CATEGORY II	DOR GUIDELINES	NUREG-0588, REV. 1 PART II STAFF RESPONSE TO PUBLIC COMMENTS	IE BULLETIN 79-01B SUPPLEMENT 2
1.0	DETERMINING DESIGN BASIS EVENT SERVICE CONDITIONS				
	1. ESTABLISHMENT OF THE QUALIFICATION PARAMETERS FOR DESIGN BASIS EVENTS	1. ESTABLISHMENT OF THE QUALIFICATION PARAMETERS FOR DESIGN BASIS EVENTS	4.1 Service Conditions Inside Containment for a Loss of Coolant Accident (LOCA)		
1.1	INSIDE CONTAINMENT				
1.1.1	TEMPERATURE AND PRESSURE				
	1.1 Temperature and Pressure Conditions Inside Containment - Loss-of-Coolant Accident (LOCA) (1) The time-dependent temperature and pressure, established for the design of the containment structure and found acceptable by the staff, may be used for environmental qualification of equipment. (2) Acceptable methods for calculating and establishing the containment pressure and temperature envelopes to which equipment should be qualified are summarized below. Acceptable methods for calculating mass and energy release rates are summarized in Appendix A. Pressurized Water Reactors (PWRs) Dry Containment - Calculate LOCA containment environment using CONTEMPT-LT or equivalent industry codes. Additional guidance is provided in Standard Review Plan (SRP) Section 6.2.1.1.A, NUREG-75/087. Ice Condenser Containment - Calculate LOCA containment environment using LOTIC or equivalent industry codes. Additional guidance is provided in SRP Section 6.2.1.1.B, NUREG-75/087. Boiling Water Reactors (BWRs) Mark I, II and III Containment - Calculate LOCA environment using methods of GESSAR Appendix 3B or equivalent industry codes. Additional guidance is provided in SRP Section 6.2.1.1.C, NUREG-75/087. (3) In lieu of using the plant-specific containment temperature and pressure design profiles for BWR and ice condenser types of plants, the generic envelope shown in Appendix C may be used for qualification testing (4) The test profiles included in Appendix A to IEEE Std. 323-1974 should not be considered an acceptable alternative in lieu of using plant-specific containment temperature and pressure design profiles unless plant-specific analysis is provided to verify the adequacy of those profiles.	1.1 Temperature and Pressure Conditions Inside Containment - Loss-of-Coolant Accident (LOCA) (1) Same as Category I. (2) Same as Category I. Pressurized Water Reactors (PWRs) Dry Containment - Use the same containment models as in Category I. The assumption of partial revaporization will be allowed. Other assumptions that reduce the temperature response of the containment will be evaluated on a case-by-case basis. Ice Condenser Containment - Same as Category I. Boiling Water Reactors (BWRs) Same as Category I. (3) Same as Category I. (4) Same as Category I.	1. Temperature and Pressure Steam Conditions - In general, the containment temperature and pressure conditions as a function of time should be based on the analyses in the FSAR. In the specific case of pressure suppression type containments, the following minimum high temperature conditions should be used: (1) BWR Drywells - 340°F for 6 hours; and (2) PWR Ice Condenser Lower Compartments - 340°F for 3 hours.		A.15 For minimum high temperature conditions in pressure-suppression-type containments, we do not require that 340 F for 6 hours be used for BWR drywells or that 340 F for 3 hours be used for PWR ice condenser lower compartments. These values are a screening device, per the Guidelines, and can be used in lieu of a plant-specific profile, provided that expected pressure and humidity conditions as a function of time are accounted for. In general, the containment temperature and pressure conditions as a function of time should be based on analyses in the FSAR. However, these conditions should bound those expected for coolant and steam line breaks inside the containment with due consideration of analytical uncertainties. The steam line break condition should include superheated conditions: the peak temperature, and subsequent temperature/pressure profile as a function of time. If containment spray is to be used, the impact of the spray on required equipment should be accounted for. The adequacy of a plant-specific profile is dependent on the assumption and design considerations at the time the profiles were developed. The DOR guidelines and NUREG-0588 provide guidance and considerations required to determine if the plant-specific profiles encompass the LOCA and HELB inside containment.

COMPARISON OF NRC EQUIPMENT ENVIRONMENTAL QUALIFICATION REQUIREMENTS AND CRITERIA

COMPARISON REFERENCE NUMBER	NUREG-0588, REV. 1 CATEGORY I	NUREG-0588, REV. 1 CATEGORY II	DOR GUIDELINES	NUREG-0588, REV. 1 PART II STAFF RESPONSE TO PUBLIC COMMENTS	IE BULLETIN 79-01B SUPPLEMENT 2
1.0	DETERMINING DESIGN BASIS EVENT SERVICE CONDITIONS (CONT.)				
1.1.1	TEMPERATURE AND PRESSURE (CONT.)				
	1.2 Temperature and Pressure Conditions Inside Containment - Main Steam Line Break (MSLB) (1) The environmental parameters used for equipment qualification should be calculated with a plant-specific model reviewed and approved by the staff. (2) Models that are acceptable for calculating containment parameters are listed in Section 1.1(2). (3) In lieu of using the plant-specific containment temperature and pressure design profiles for BWR and ice condenser plants, the generic envelope shown in Appendix C may be used. (4) The test profiles included in Appendix A to IEEE Std. 323-1974 should not be considered an acceptable alternative in lieu of using plant-specific containment temperature and pressure design profiles unless plant-specific analysis is provided to verify the adequacy of those profiles. (5) Where qualification has been completed but only LOCA conditions were considered, it must be demonstrated that the LOCA qualification conditions exceed or are equivalent to the maximum calculated MSLB conditions. The following technique is acceptable: (a) Calculate the peak temperature envelope from an MSLB using a model based on the staff's approved assumptions defined in Section 1.1(2). (b) Show that the peak surface temperature of the component to be qualified does not exceed the LOCA qualification temperature by the method discussed in Item 2 of Appendix B. (c) If the calculated surface temperature exceeds the qualification temperature, the staff requires that (i) requalification testing be performed with appropriate margins, or (ii) qualified physical protection be provided to assure that the surface temperature will not exceed the actual qualification temperature. For plants that are currently being reviewed, or will be submitted for an operating license review within six months from issue date of this report, compliance with items (i) or (ii) above may represent a substantial impact. For these plants, the staff will consider additional information submitted by the applicant to demonstrate that the equipment can maintain its functional operability if its surface temperature rises to the value calculated.	1.2 Temperature and Pressure Conditions Inside Containment - Main Steam Line Break (MSLB) (1) Where qualification has not been completed, the environmental parameters used for equipment qualification should be calculated using a plant-specific model based on the staff-approved assumptions discussed in Item 1 of Appendix B. (2) Other models that are acceptable for calculating containment parameters are listed in Section 1.1(2). (3) Same as Category I. (4) Same as Category I. (5) Where qualification has been completed but only LOCA conditions were considered, then it must be demonstrated that the LOCA qualification conditions exceed or are equivalent to the maximum calculated MSLB conditions. The following technique is acceptable: (a) Calculate the peak temperature from an MSLB using a model based on the staff's approved assumptions discussed in Item 1 of Appendix B. (b) Same as Category I Section 1.2(5)(b). (c) If the calculated surface temperature exceeds the qualification temperature, the staff requires that (i) additional justification be provided to demonstrate that the equipment can maintain its required functional operability if its surface temperature reaches the calculated value or (ii) requalification testing be performed with appropriate margins, or (iii) qualified physical protection be provided to assure that the surface temperature will not exceed the actual qualification temperature.	4.1 Service Conditions for a PWR Main Steam Line Break (MSLB) Inside Containment Equipment required to function in a steam line break environment must be qualified for the high temperature and pressure that could result. In some cases the environmental stress on exposed equipment may be higher than that resulting from a LOCA. In others it may be no more severe than for a LOCA due to the automatic operation of a containment spray system. 1. Temperature and Pressure Steam Conditions - Equipment qualified for a LOCA environment is considered qualified for a MSLB accident environment in plants with automatic spray systems not subject to disabling single component failures. This position is based on the "Best Estimate" calculation of a typical plant peak temperature and pressure and a thermal analysis of typical components inside containment. The final acceptability of this approach, i.e., use of the "Best Estimate," is pending the completion of Task Action Plan A-21, Main Steamline Break Inside Containment. Class IE equipment installed in plants without automatic spray systems or plants with spray systems subject to disabling single failures or delayed initiation should be qualified for a MSLB accident environment determined by a plant specific analysis. Acceptable methods for performing such an analysis for operating reactors are provided in Section 1.3 for Category II plants in NUREG-0588, Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment.	NUREG-0588 COMMENTS Resolution 10 - (1.2(5)(a)) The intent of Section 1.2(5)(a) Category II is to require a calculation for the peak temperature envelope (not a single-point calculation). With regard to the second point, Section 1.2(5)(c) for Category I requires that testing be the principal qualification method. These plants are in the early stages of design and have the opportunity for such equipment qualification testing at the anticipated bounding design conditions. Category II, which applies to near-term operating license (NTOL) applications and operating reactors, recognizes the vintage of the equipment and allows additional justification to provide, by analytical means, to demonstrate that the equipment can maintain its required functional operability if the calculated MSLB temperature at or near the surface of the equipment exceeds the LOCA test temperature (for which the equipment has already been qualified). This type of qualification has been and will be applied on older NTOL plants.	A.24 Temperature measurements are required during the qualification testing to establish that the component was subjected to the most severe temperature environment postulated to occur. These temperature measurements are required to be made as close to the component surface as practicable to ensure that they are representative of the environment in which the component is tested. The surface temperature of the component, although not specifically required, is considered to be a conservative measurement of the test temperature environment.

COMPARISON OF NRC EQUIPMENT ENVIRONMENTAL QUALIFICATION REQUIREMENTS AND CRITERIA

COMPARISON REFERENCE NUMBER	NUREG-0588, REV. 1 CATEGORY I	NUREG-0588, REV. 1 CATEGORY II	DOR GUIDELINES	NUREG-0588, REV. 1 PART II STAFF RESPONSE TO PUBLIC COMMENTS	IE BULLETIN 79-01B SUPPLEMENT 2
1.0	DETERMINING DESIGN BASIS EVENT SERVICE CONDITIONS (CONT.)				
1.1.2	CHEMICAL SPRAY				
	1.3 <u>Effects of Chemical Spray</u> (1) The effects of caustic spray should be addressed for the equipment qualification. The concentration of caustics used for qualification should be equivalent to or more severe than those used in the plant containment spray system. If the chemical composition of the caustic spray can be affected by equipment malfunctions, the most severe caustic spray environment that results from a single failure in the spray system should be assumed. See SRP Section 6.5.2 (NUREG-75/087), paragraph II, item (e) for caustic spray solution guidelines	1.3 <u>Effects of Chemical Spray</u> Same as Category I.	4.1 <u>Service Conditions Inside Containment for a Loss of Coolant Accident (LOCA)</u> d. <u>Containment Sprays</u> - Equipment exposed to chemical sprays should be qualified for the most severe chemical environment (acidic or basic) which could exist. Demineralized water sprays should not be exempt from consideration as a potentially adverse service condition. 4.2 <u>Service Conditions for a PWR Main Steam Line Break (MSLB) Inside Containment</u> d. <u>Chemical Sprays</u> - Same as Section 4.1 above.	<u>Comment</u> 13 Should be changed to: "The concentration of caustics used for qualification should be equivalent to or more severe than those used in the plant containment spray system, during both the initiation and recirculation phases." <u>Resolution</u> 13 - (1.3) The staff concurs. This change will be considered in the proposed rulemaking and/or the revision to Regulatory Guide 1.89 to be issued for public comment in December 1981. <u>Resolution</u> 61 - (2.2(8)) Chemical spray ingress (if any) is one area of concern addressed by the position. Pressure is considered a driving force influencing ingress into vital components through materials such as seals, jackets, and so forth. It is therefore prudent during testing to ensure that chemical (or demineralized water) sprays are introduced at or as close to the simulated maximum containment peak pressure conditions (if not already introduced before the maximum peak pressure conditions are reached).	

COMPARISON OF NRC EQUIPMENT ENVIRONMENTAL QUALIFICATION REQUIREMENTS AND CRITERIA

COMPARISON REFERENCE NUMBER	NUREG-0588, REV. 1 CATEGORY I	NUREG-0588, REV. 1 CATEGORY II	DOR GUIDELINES	NUREG-0588, REV. 1 PART II STAFF RESPONSE TO PUBLIC COMMENTS	IE BULLETIN 79-01B SUPPLEMENT 2
1.0	DETERMINING DESIGN BASIS EVENT SERVICE CONDITIONS (CONT.)				
1.1.3	RADIATION CONDITIONS				
	1.4 <u>Radiation Conditions Inside and Outside Containment</u> The radiation environment for qualification of equipment should be based on the normally expected radiation environment over the equipment qualified life, plus that associated with the most severe design basis accident (DBA) during or following which that equipment must remain functional. It should be assumed that the DBA related environmental conditions occur at the end of the equipment qualified life. The sample calculations in Appendix D and the following positions provide an acceptable approach for establishing radiation limits for qualification. Additional radiation margins identified in Section 6.3.1.5 of IEEE Std 323-1974 for qualification type testing are not required if these methods are used. (1) The source term to be used in determining the radiation environment associated with the design basis LOCA should be taken as an instantaneous release from the fuel to the atmosphere of 100 percent of the noble gases, 50 percent of the iodines, and 1 percent of the remaining fission products. For all other non-LOCA design basis accident conditions, a source term involving an instantaneous release from the fuel to the atmosphere of 10 percent of the noble gases (except Kr-85 for which a release of 30 percent should be assumed) and 10 percent of the iodines is acceptable	1.4 <u>Radiation Conditions Inside and Outside Containment</u> Same as Category I.	4.1 <u>Service Conditions Inside Containment for a Loss of Coolant Accident (LOCA)</u> 2. <u>Radiation</u> - When specifying radiation service conditions for equipment exposed to radiation during normal operating and accident conditions, the normal operating dose should be added to the dose received during the course of an accident. Guidelines for evaluating beta and gamma radiation service conditions for general areas inside containment are provided below. Radiation service conditions for equipment located directly above the containment sump, in the vicinity of filters, or submerged in contaminated liquids must be evaluated on a case by case basis. Guidelines for these evaluations are not provided in this document. <u>Gamma Radiation Doses</u> - A total gamma dose radiation service condition of 2×10^7 RADS is acceptable for Class IE equipment located in general areas inside containment for PWRs with dry type containments. Where a dose less than this value has been specified, an application specific evaluation must be performed to determine if the dose specified is acceptable. Procedures for evaluating radiation service conditions in such cases are provided in Appendix D. The procedures in Appendix D are based on the calculation for a typical PWR reported in Appendix D of NUREG-0588. Gamma dose radiation service conditions for BWRs and PWRs with ice condenser containments must be evaluated on a case by case basis. Since the procedures in Appendix D are based on a calculation for a typical PWR with a dry type containment, they are not directly applicable to BWRs and other containment types. However, doses for these other plant configurations may be evaluated using similar procedures with conservative dose assumptions and adjustment factors developed on a case by case basis.	<u>Resolution</u> 22 - (1.4) Section 1.4 requires that the qualification dose should be the sum of the normal and accident doses. Appendix D addresses only the accident doses. It should be noted that the dose values in Appendix D are provided for illustrative purposes and they may not be appropriate for plant-specific application. Any modifications to position 1.4 (14) will be incorporated in the final rulemaking to be issued for public comment in December 1981.	A.19 Yes. Gamma equivalents may be used when consideration of the contributions of beta exposure have been included in accordance with the guidance given in the DOR guidelines and NUREG-0588. Cobalt 60 is one acceptable gamma radiation source for environmental qualification of safety-related equipment. Cesium 137 may also be used.

COMPARISON OF NRC EQUIPMENT ENVIRONMENTAL QUALIFICATION REQUIREMENTS AND CRITERIA

COMPARISON REFERENCE NUMBER	NUREG-0588, REV. 1 CATEGORY I	NUREG-0588, REV. 1 CATEGORY II	DOR GUIDELINES	NUREG-0588, REV. 1 PART II STAFF RESPONSE TO PUBLIC COMMENTS	IE BULLETIN 79-01B SUPPLEMENT 2
1.0	DETERMINING DESIGN BASIS EVENT SERVICE CONDITIONS (CONT.)				
1.1.3	RADIATION CONDITIONS (CONT.)				
	1.4 <u>Radiation Conditions Inside and Outside Containment</u> (2) The calculation of the radiation environment associated with design basis accidents should take into account the time-dependent transport of released fission products within various regions of containment and auxiliary structures. (3) The initial distribution of activity within the containment should be based on a mechanistically rational assumption. Hence, for compartmented containments, such as in a BWR, a large portion of the source should be assumed to be initially contained in the drywell. The assumption of uniform distribution of activity throughout the containment at time zero is not appropriate. (4) Effects of ESF systems, such as containment sprays and containment ventilation and filtration systems, which act to remove airborne activity and redistribute activity within containment, should be calculated using the same assumptions used in the calculation of offsite dose. See SRP Section 15.6.5 (NUREG-75/087) and the related sections referenced in the Appendices to that section. (5) Natural deposition (i.e., plate-out) of airborne activity should be determined using a mechanistic model and best estimates for the model parameters. The assumption of 50 percent instantaneous plate-out of the iodine released from the core should not be made. Removal of iodine from surfaces by steam condensate flow or washoff by the containment spray may be assumed if such effects can be justified and quantified by analysis or experiment. (6) For unshielded equipment located in the containment, the gamma dose and dose rate should be equal to the dose and dose rate at the centerpoint of the containment plus the contribution from location dependent sources such as the sump water and plate-out, unless it can be shown by analyses that location and shielding of the equipment reduces the dose and dose rate (7) For unshielded equipment, the beta doses at the surface of the equipment should be the sum of the airborne and plate-out sources. The airborne beta dose should be taken as the beta dose calculated for a point at the containment center. (8) Shielded components need be qualified only to the gamma radiation levels required, provided an analysis or test shows that the sensitive portions of the component or equipment are not exposed to beta radiation or that the effects of beta radiation heating and ionization have no deleterious effects on component performance		4.1 <u>Service Conditions Inside Containment for a Loss of Coolant Accident (LOCA)</u> <u>Beta Radiation Doses</u> - Beta radiation doses generally are less significant than gamma radiation doses for equipment qualification. This is due to the low penetrating power of beta particles in comparison to gamma rays of equivalent energy. Of the general classes of electrical equipment in a plant (e.g., cables, instrument transmitters, valve operators, containment penetrations), electrical cable is considered the most vulnerable to damage from beta radiation. Assuming a TID 14844 source term, the average maximum beta energy and isotopic abundance will vary as a function of time following an accident. If these parameters are considered in a detailed calculation, the conservative beta surface dose of 1.40 x 10^8 RADS reported in Appendix D of NUREG-0588 would be reduced by approximately a factor of two within 30 mils of the surface of electrical cable insulation of unit density. An additional 40 mils of insulation (total of 70 mils) results in another factor of 10 reduction in dose. Any structures or other equipment in the vicinity of the equipment of interest would act as shielding to further reduce beta doses. If it can be shown, by assuming a conservative unshielded surface beta dose of 2.0 x 10^8 RADS and considering the shielding factors discussed here, that the beta dose to radiation sensitive equipment internals would be less than or equal to 10% of the total gamma dose to which an item of equipment has been qualified, then that equipment may be considered qualified for the total radiation environment (gamma plus beta). If this criterion is not satisfied the radiation service condition should be determined by the sum of the gamma and beta doses. 4.2 <u>Service Conditions for a PWR Main Steam Line Break (MSLB) Inside Containment</u> 3. <u>Radiation</u> - Same as Section 4.1 above except that a conservative gamma dose of 2 x 10^6 RADS is acceptable. 4.3 <u>Service Conditions Outside of Containment</u> 4.3.1 <u>Areas Subject to a Severe Environment as a Result of a High Energy Line Break (HELB)</u> Service conditions for areas outside containment exposed to a HELB were evaluated on a plant by plant basis as part of a program initiated by the staff in December, 1972 to evaluate the effects of a HELB. The equipment required to mitigate the event was also identified. This equipment should be qualified for the service conditions reviewed and approved in the HELB Safety Evaluation Report for each specific plant.		A.18 Both the DOR guidelines and NUREG-0588 are similar in that they provide the methods for determining the radiation source term when considering LOCA events inside containment (100% noble gases/50% iodine/1% particulates). These methods consider the radiation source term resulting from an event which completely depressurizes the primary system and releases the source term inventory to the containment. NUREG-0578 provides the radiation source term to be used for determining the qualification doses for equipment in close proximity to recirculating fluid systems inside and outside of containment as a result of LOCA. This method considers a LOCA event in which the primary system may not depressurize and the source term inventory remains in the coolant. NUREG-0588 also provides the radiation source term to be used for qualifying equipment following non-LOCA events both inside and outside containment (10% noble gases/10% iodine/0% particulates). When developing radiation source terms for equipment qualification, the licensee must ensure consideration is given to those events which provide the most bounding conditions. The following table summarizes these considerations: (blank) — <u>LOCA</u> — <u>NON-LOCA HELB</u> Outside Containment — NUREG-0578 (100/50/1 in RCS) — NUREG-0588 (10/10/0 in RCS) Inside Containment — <u>Larger of</u> NUREG-0588 (100/50/1 in containment — NUREG-0588 (10/10/0 in RCS)

Franklin Research Center
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COMPARISON OF NRC EQUIPMENT ENVIRONMENTAL QUALIFICATION REQUIREMENTS AND CRITERIA

COMPARISON REFERENCE NUMBER	NUREG-0588, REV. 1 CATEGORY I	NUREG-0588, REV. 1 CATEGORY II	DOR GUIDELINES	NUREG-0588, REV. 1 PART II STAFF RESPONSE TO PUBLIC COMMENTS	IE BULLETIN 79-01B SUPPLEMENT 2
1.0	DETERMINING DESIGN BASIS EVENT SERVICE CONDITIONS (CONT.)				
1.1.3	RADIATION CONDITIONS (CONT.)				
	1.4 <u>Radiation Conditions Inside and Outside Containment</u> (9) Cables arranged in cable trays in the containment should be assumed to be exposed to half the beta radiation dose calculated for a point at the center of the containment plus the gamma ray dose calculated in accordance with Section 1.4(6). This reduction in beta dose is allowed because of the localized shielding by other cables plus the cable tray itself. (10) Paints and coatings should be assumed to be exposed to both beta and gamma rays in assessing their resistance to radiation. Plate-out activity should be assumed to remain on the equipment surface unless the effects of the removal mechanisms, such as spray wash-off or steam condensate flow, can be justified and quantified by analysis or experiment. (11) Components of the emergency core cooling system (ECCS) located outside containment (e.g., pumps, valves, seals and electrical equipment) should be qualified to withstand the radiation equivalent to that penetrating the containment, plus the exposure from the sump fluid using assumptions consistent with the requirements stated in Appendix K to 10 CFR Part 50 (12) Equipment that may be exposed to radiation doses below 10^4 rads should not be considered to be exempt from radiation qualification, unless analysis supported by test data is provided to verify that these levels will not degrade the operability of the equipment below acceptable values. (13) The staff will accept a given component to be qualified provided it can be shown that the component has been qualified to integrated beta and gamma doses which are equal to or higher than those levels resulting from an analysis similar in nature and scope to that included in Appendix D (which uses the source term given in item (1) above), and that the component incorporates appropriate factors pertinent to the plant design and operating characteristics, as given in these general guidelines. (14) (14) When a conservative analysis has not been provided by the applicant for staff review, the staff will use the radiation environment guidelines contained in Appendix D, suitably corrected for the differences in reactor power level, type, containment size, and other appropriate factors.		4.3.2 <u>Areas Where Fluids are Recirculated from Inside Containment to Accomplish Long-Term Core Cooling Following a LOCA</u> 2. <u>Radiation</u> - Due to differences in equipment arrangement within these areas and the significant effect of this factor on doses, radiation service conditions must be evaluated on a case by case basis. In general, a dose of at least 4 × 10^6 RADS would be expected. 4.3.3 <u>Areas Normally Maintained at Room Conditions</u> Class 1E equipment located in these areas does not experience significant stress due to a change in service conditions during a design basis event. This equipment was designed and installed using standard engineering practices and industry codes and standards (e.g., ANSI, NEMA, National Electric Code). Based on these factors, failures of equipment in these areas during a design basis event are expected to be random except to the extent that they may be due to aging or failures of air conditioning or ventilation systems. Therefore, no special consideration need be given to the environmental qualification of Class 1E equipment in these areas provided the <u>aging</u> requirements discussed in Section 7.0 below are satisfied and the areas are maintained at room conditions by redundant air conditioning or ventilation systems served by the onsite emergency electrical power system. Equipment located in areas not served by redundant systems powered from onsite emergency sources should be qualified for the environmental extremes which could result from a failure of the systems as determined from a plant specific analysis.	<u>Resolution 32</u> - (1.4(7)) The doses calculated using the methods of Appendix D are estimates at the surface of the equipment. The staff does not wish to use the approach of specifying a dose at a predetermined critical depth because the critical depth doses are dependent on the absorbing materials (which is different for different equipment). The beta dose from plate-out on cables cannot be ignored. The intent of position 1.4(7) is to explicitly require the consideration of all radiation sources when calculating the qualification doses, which includes the beta dose from plate-out sources on cables. <u>Resolution</u> 33 - (1.4(7)) The staff concurs. Position 1.4(7) shall be interpreted to include all potential sources when calculating qualification doses (which would include both airborne and plated-out sources). <u>Resolution</u> 35 - (1.4(7), (8), (9), (10), (14)) The staff agrees with the comment. Any modification to the positions will be considered during the final rulemaking to be issued for public comment in December 1981. It is the staff's belief that the qualification dose should account for all types of radiation present at the equipment location. The staff permits the reduction of calculated beta doses to account for localized shielding (that is, component and/or structural shielding) and has provided additional guidance in the DOR guideline document. When a significant beta dose reduction can be justified, the staff expects the equipment qualification dose to equal or exceed the gamma radiation dose calculated using assumptions and models similar to those in Appendix D. For any safety-related component not meeting the calculated qualification values, justification for the adequacy of the design should be provided, or a modification of the design to satisfy the above radiation requirements may be warranted. Replacement equipment or equipment that has not yet been qualified should conform to the Category I requirements. <u>Resolution</u> 37 - (1.4(11)) It is not the staff's intent to imply that testing is the only acceptable method for demonstrating qualification adequacy of equipment that will be exposed to low-level radiation. Other methods (such as analysis), if they are supported by test data, literature search (on identical or sufficiently similar material and/or equipment where extrapolation of the data to the actual equipment being qualified is feasible), or operating history (if it is supported by test data) may also be found acceptable. The staff concurs that there may be information available to indicate that many materials used today have radiation dose and dose-rate damage thresholds greater than 10^4 rads. However, there are also components that may be made of materials susceptible to low level radiation dose and dose-rate damage (for example, Teflon TFE and integrated circuits). Therefore, low-level radiation should not be dismissed on a generic basis and should be evaluated on a case-by-case basis.	

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1.0	DETERMINING DESIGN BASIS EVENT SERVICE CONDITIONS (CONT.)				
1.2	OUTSIDE CONTAINMENT				
1.2.1	TEMPERATURE, PRESSURE, HUMIDITY, AND RADIATION				
	1.5 Environmental Conditions for Outside Containment (1) Equipment located outside containment that could be subjected to high-energy pipe breaks should be qualified to the conditions resulting from the accident for the duration required. The techniques to calculate the environmental parameters described in Sections 1.1 through 1.4 above should be applied. (2) Equipment located in general plant areas outside containment where equipment is not subjected to a design basis accident environment should be qualified to the normal and abnormal range of environmental conditions postulated to occur at the equipment location. (3) Equipment not served by Class IE environmental support systems, or served by Class IE support systems that may be secured during plant operation or shutdown, should be qualified to the limiting environmental conditions that are postulated for that location, assuming a loss of the environmental support system.	1.5 Environmental Conditions for Outside Containment (1) Equipment located outside containment that could be subjected to high-energy pipe breaks should be qualified to the conditions resulting from the accident for the duration required. The techniques to calculate the environmental parameters described in Sections 1.1 through 1.4 (Category II) above should be applied. (2) Same as Category I. (3) Same as Category I; or, there may be designs where a loss of the environmental support system may expose some equipment to environments that exceed the qualified limits. For these designs, appropriate monitoring devices should be provided to alert the operator that abnormal conditions exist and to permit an assessment of the conditions that occurred in order to determine if corrective action, such as replacing any affected equipment, is warranted.	4.3 Service Conditions Outside of Containment 4.3.1 Areas Subject to a Severe Environment as a Result of a High Energy Line Break (HELB) Service conditions for areas outside containment exposed to a HELB were evaluated on a plant by plant basis as part of a program initiated by the staff in December, 1972 to evaluate the effects of a HELB. The equipment required to mitigate the event was also identified. This equipment should be qualified for the service conditions reviewed and approved in the HELB Safety Evaluation Report for each specific plant. 4.3.2 Areas Where Fluids are Recirculated from Inside Containment to Accomplish Long-Term Core Cooling Following a LOCA 1. Temperature and Relative Humidity - One hundred percent relative humidity should be established as a service condition in confined spaces. The temperature and pressure as a function of time should be based on the plant unique analysis reported in the FSAR. 3. Submergence - Not applicable. 4. Chemical Sprays - Not applicable. 4.3.3 Areas Normally Maintained at Room Conditions Class IE equipment located in these areas does not experience significant stress due to a change in service conditions during a design basis event. This equipment was designed and installed using standard engineering practices and industry codes and standards (e.g., ANSI, NEMA, National Electric Code). Based on these factors, failures of equipment in these areas during a design basis event are expected to be random except to the extent that they may be due to aging or failures of air conditioning or ventilation systems. Therefore, no special consideration need be given to the environmental qualification of Class IE equipment in these areas provided the aging requirements discussed in Section 7.0 below are satisfied and the areas are maintained at room conditions by redundant air conditioning or ventilation systems served by the onsite emergency electrical power system. Equipment located in areas not served by redundant systems powered from onsite emergency sources should be qualified for the environmental extremes which could result from a failure of the systems as determined from a plant specific analysis.	Resolution 38 - (1.5(2)) IEEE Standard 323-1974 states that the service conditions required to be addressed include "Environmental conditions expected as a result of normal operating requirements, expected extremes in operating requirements (i.e., abnormal environments) and postulated conditions appropriate for the design basis events of the station." Therefore, the staff does not agree with the conclusions reached in the comment. The main purpose of qualification is to verify the performance adequacy and/or the capability of a design. A specification alone does not provide this verification. A purchase specification supported by certificate of compliance which is based on test or test and analysis could constitute acceptance qualification documentation. It should also be noted that the position in Section 2.1(4) does not limit the qualification to only test or analysis. Resolution 39 - (1.5(3)) If the redundant systems are separate and independent so that a single failure will not render both systems inoperable, the interpretation of the comment is correct. There may be designs and/or procedures, however, that may shut down both redundant and independent environment support systems during plant outages. For these designs, a loss of both redundant support systems should be assumed. Resolution 41 - (1.5) The staff concurs in part. If any equipment failure resulting from an HELB will be detrimental to safety (even though this equipment is not necessary for mitigating the consequence of the accident), that equipment should also be qualified to the HELB conditions (see Section 3.1(3)).	

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COMPARISON REFERENCE NUMBER	NUREG-0588, REV. 1 CATEGORY I	NUREG-0588, REV. 1 CATEGORY II	DOR GUIDELINES	NUREG-0588, REV. 1 PART II STAFF RESPONSE TO PUBLIC COMMENTS	IE BULLETIN 79-01B SUPPLEMENT 2
2.0	QUALIFICATION METHODS				
2.1	SELECTION OF METHODS				
	2.1 <u>Selection of Methods</u> (1) Qualification methods should conform to the requirements defined in IEEE Std. 323-1974. (2) The choice of the methods selected is largely a matter of technical judgment and availability of information that supports the conclusions reached. Experience has shown that qualification of equipment subjected to an accident environment without test data is not adequate to demonstrate functional operability. In general, the staff will not accept analysis in lieu of test data unless (a) testing of the component is impractical due to size limitations, and (b) partial type test data is provided to support the analytical assumptions and conclusions reached. (3) The environmental qualification of equipment exposed to DBA environments should conform to the following positions. The bases should be provided for the time interval required for operability of this equipment. The operability and failure criteria should be specified and the safety margins defined. (a) Equipment that must function in order to mitigate any accident should be qualified by test to demonstrate its operability for the time required in the environmental conditions resulting from that accident. (b) Any equipment (safety-related or non-safety-related) that need not function in order to mitigate any accident, but that must not fail in a manner detrimental to plant safety should be qualified by test to demonstrate its capability to withstand any accident environment for the time during which it must not fail.	2.1 <u>Selection of Methods</u> (1) Qualification methods should conform to the requirements defined in IEEE Std. 323-1971. (2) Same as Category I. (3) Same as Category I.	4.3.3 <u>Areas Normally Maintained at Room Conditions</u> Class IE equipment located in these areas does not experience significant stress due to a change in service conditions during a design basis event. This equipment was designed and installed using standard engineering practices and industry codes and standards (e.g., ANSI, NEMA, National Electric Code). Based on these factors, failures of equipment in these areas during a design basis event are expected to be random except to the extent that they may be due to aging or failures of air conditioning or ventilation systems. Therefore, no special consideration need be given to the environmental qualification of Class IE equipment in these areas provided the aging requirements discussed in Section 7.0 below are satisfied and the areas are maintained at room conditions by redundant air conditioning or ventilation systems served by the onsite emergency electrical power system. Equipment located in areas not served by redundant systems powered from onsite emergency sources should be qualified for the environmental extremes which could result from a failure of the systems as determined from a plant specific analysis.	<u>Resolution</u> 44 - (2.1(3)) The staff agrees with the comment. The term "safety margins" is intended to be the same as the term "margin" used in IEEE 323-1974. <u>Resolution</u> 45 - (2.1(3)) Operability refers to assuring that the performance characteristics of the equipment that are necessary to perform a safety function are satisfied, including but not limited to accuracy, response time, and so forth. Test margin should be applied as described in Section 3.0 of the document. <u>Resolution</u> 46 - (2.1(2)) The staff concurs in part; clarification of this requirement will be considered in final rulemaking. The staff maintains, however, that for active electrical equipment subjected to a DBA environment, type testing is the preferred qualification method. Other methods may be justified and will be evaluated on a case-by-case basis. <u>Resolution</u> 47 - (2.1(3)) Equipment that has been shown and justified to be unrelated to accident mitigation or plant safety is exempt from qualification. <u>Resolution</u> 48 - (2.1(3)) The position addresses designs where equipment or systems have been incorrectly classified as non-Class IE strictly on the basis that they did not have to perform a specific safety function (such as actuation). The designs may have not factored in the broader function of determining whether or not their failure or improper actuation could also effect safety. It is the staff's intent to assure that this broader functional scope is factored into the design and as such, the qualification of some previously classified non-Class IE equipment may be warranted. It is not the staff's intent to require qualification of all non-safety-related equipment. (See also the staff response to Comment 4 and Comment 47). Regarding the second point in the comment, the staff does not agree with the recommendation to delete this requirement from NUREG-0588. Resolution and implementation of the generic issue identified in NUREG-0588 are independent of the requirement stated herein.	

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2.0	QUALIFICATION METHODS (CONT.)				
2.1	SELECTION OF METHODS (CONT.)				
	(c) Equipment that need not function in order to mitigate any accident and whose failure in any mode in any accident environment is not detrimental to plant safety need only be qualified for its non-accident service environment. Although actual type testing is preferred, other methods when justified may be found acceptable. The bases should be provided for concluding that such equipment is not required to function in order to mitigate any accident, and that its failure in any mode in any accident environment is not detrimental to plant safety. (4) For environmental qualification of equipment subject to events other than a DBA, which result in abnormal environmental conditions, actual type testing is preferred. However, analysis or operating history, or any applicable combination thereof, coupled with partial type test data may be found acceptable, subject to the applicability and detail of information provided.	(4) Same as Category I.		Comment 49 This paragraph (Section 2.1(3)(c)) should be clarified to indicate applicability to safety-related equipment only. Non-safety-related equipment is not environmentally qualified unless it falls into Category 2.1(3)(b). Resolution 51 - (2.1(3)) For electrical equipment located inside or outside containment that may be exposed to high energy line breaks (for example, LOCA, MSLB, feedwater line rupture), analysis alone is generally inadequate to demonstrate functional operability such as accuracy or response time, or to verify seal integrity (as in connectors), or even to detect intermittent or spurious failures. Although some analysis may be used when the testing is the principal qualification method, that analysis should be limited to extrapolations of data or to analyzing similarities in equipment or materials. In either case, analytical assumptions should be be verifiable or supported by test data. Recognizing the complex interaction of the environment on materials and equipment (such as aging or simultaneous vs. sequential effects) the staff does not agree that analysis by itself is an acceptable alternative for qualifying equipment required to function in the above-mentioned hostile environments. (See exceptions in Section 2.4).	
2.2	QUALIFICATION BY TEST				
	2.2 Qualification by Test (1) The failure criteria should be established prior to testing. (2) Test results should demonstrate that the equipment can perform its required function for all service conditions postulated (with margin) during its installed life. (3) The items described in Section 6.3 of IEEE Std. 323-1974 supplemented by items (4) through (12) below constitute acceptable guidelines for establishing test procedures (4) When establishing the simulated environmental profile for qualifying equipment located inside containment, it is preferred that a single profile be used that envelopes the environmental conditions resulting from any design basis event during any mode of plant operation (e.g., a profile that envelopes the conditions produced by the main steamline break and loss-of-coolant accidents). (5) Equipment should be located above flood level or protected against submergence by locating the equipment in qualified watertight enclosures. Where equipment is located in watertight enclosures, qualification by test or analysis should be used to demonstrate the adequacy of such protection. Where equipment could be submerged, it should be identified and demonstrated to be qualified by test for the duration required.	2.2 Qualification by Test (1) Same as Category I. (2) Same as Category I. (3) The items described in Section 5.2 of IEEE Std. 323-1971 supplemented by items (4) through (12) below constitute acceptable guidelines for establishing test procedures. (4) Same as Category I. (5) Same as Category I.	5.2 Qualification by Type Testing The evaluation of test plans and results should include consideration of the following factors: 1. Simulated Service Conditions and Test Duration - The environment in the test chamber should be established and maintained so that it envelopes the service conditions defined in accordance with Section 4.0 above. The time duration of the test should be at least as long as the period from the initiation of the accident until the temperature and pressure service conditions return to essentially the same levels that existed before the postulated accident. A shorter test duration may be acceptable if specific analyses are provided to demonstrate that the materials involved will not experience significant accelerated thermal aging during the period not tested. 2. Test Specimen - The test specimen should be the same model as the equipment being qualified. The type test should only be considered valid for equipment identical in design and material construction to the test specimen. Any deviations should be evaluated as part of the qualification documentation (see also Section 6.0 below).	Resolution 63 - (2.2(10)) The loss of offsite power is assumed concurrently with a design basis accident (as in the case of LOCA, MSLB, and so forth). As a result of sequencing the loads onto the diesel generators, power and frequency variations will be sensed on selected equipment such as valves, motors, and relays, and may affect their performance characteristics (for example, response time) and negate their safety function. If equipment can sense these effects, these variations should be accounted for in the test program. Resolution 65 - (2.2(11)) The staff agrees in concept with the comment. It is not the staff's intent to require quantitative testing to ensure equipment operability in dusty environments, but rather to highlight a potential failure mechanism. Equipment susceptibility to dust should be considered when qualifying safety-related equipment and be accounted for in the interface requirements via, for example, in improved periodic maintenance, or by the use of protective covers. The staff is currently in the process of rulemaking and will consider the recommendations expressed in the above comments, in the "Final" position. Resolution 59 - (2.2(5)) The staff concurs in part. Shorter test periods and analytical extrapolation may be found acceptable if adequately justified. This justification should be included as part of the qualification documentation. Analysis by itself, however, may not be adequate (see staff response to Comment No. 51 for additional information).	

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2.0	*QUALIFICATION METHODS (CONT.)*				
2.2	QUALIFICATION BY TEST (CONT.)				
	(6) The temperature to which equipment is qualified, when exposed to the simulated accident environment, should be defined by thermocouple readings on or as close as practical to the surface of the component being qualified. (7) Performance characteristics of equipment should be verified before, after, and periodically during testing throughout its range of required operability. (8) Caustic spray should be incorporated during simulated event testing at the maximum pressure and at the temperature conditions that would occur when the onsite spray systems actuate. (9) The operability status of equipment should be monitored continuously during testing. For long-term testing, however, monitoring at discrete intervals should be justified if used. (10) Expected extremes in power supply voltage range and frequency should be applied during simulated event environmental testing (11) Dust environments should be addressed when establishing qualification service conditions. (12) Cobalt-60 is an acceptable gamma radiation source for environmental qualification.	(6) Same as Category I. If there were no thermocouples located near the equipment during the tests, heat transfer analysis should be used to determine the temperature at the component. (Acceptable heat transfer analysis methods are provided in Appendix B.) (7) Same as Category I. (8) Same as Category I. (9) Same as Category I. (10) Same as Category I. (11) Same as Category I. (12) Same as Category I.	5.2 <u>Qualification by Type Testing</u> 5. <u>Functional Testing and Failure Criteria</u> - Operational modes tested should be representative of the actual application requirements (e.g., components which operate normally energized in the plant should be normally energized during the tests, motor and electrical cable loading during the test should be representative of actual operating conditions). Failure criteria should include instrument accuracy requirements based on the maximum error assumed in the plant safety analyses. If a component fails at any time during the test, even in a so called "fail safe" mode, the test should be considered inconclusive with regard to demonstrating the ability of the component to function for the entire period prior to the failure. 6. <u>Installation Interfaces</u> - The equipment mounting and electrical or mechanical seals used during the type test should be representative of the actual installation for the test to be considered conclusive. The equipment qualification program should include an as-built inspection in the field to verify that equipment was installed as it was tested. Particular emphasis should be placed on common problems such as protective enclosures installed upside down with drain holes at the top and penetrations in equipment housings for electrical connections being left unsealed or susceptible to moisture incursion through stranded conductors.	<u>Resolution</u> 58 - (2.2(6)) The staff agrees with the intent of the comment. It should be noted that the objective of the position is to ensure, by independent verification, that the equipment or component was exposed to the bulk temperature equivalent to or more severe than that temperature assumed in the bounding envelope derived from the accident analysis. Temperature sensors (not necessarily limited to thermocouples) located only on the inlet piping of the test chambers may not be indicative of the bulk temperature at the component being tested. The intent is to ensure that temperature sensors are located as close as practical to the components being qualified. It may also be prudent to provide temperature sensors that in addition to monitoring bulk temperature would also monitor the surface temperature of the equipment. This would facilitate the comparative studies discussed in Section 1.2(3)(b) of the NUREG. Without these readings, the use of the more conservative comparison to the "bulk" LOCA test temperature would be warranted. See also staff response to Comment No. 9.) <u>Resolution</u> 48 - (2.2(9)) The intent of Section 2.2(9) is to ensure that intermittent failures in equipment--such as momentary change of state of bistables (that is, contact chatter), a cyclic variation in a transmitter output or a valve position variation--have been accounted for in the qualification testing program. Where intermittent failures in equipment can negate a safety function, the test program should include provisions to monitor selected parameters on a continuous basis in order to detect these failures (if any). It is recognized that certain equipment requires long-term testing (for example, postaccident monitoring equipment) where around the clock monitoring is difficult to accomplish. For this category of equipment, continuous monitoring for spurious or intermittent operation during periodic intervals may be justified. <u>Resolution</u> 55 - (2.2(12)) The staff currently has a research effort with Sandia Laboratory to investigate the adequacy of qualifying equipment for both gamma and beta radiation environments by using only a gamma radiation source. While the results are very preliminary, there does not seem to be any significant problem in using only a gamma source to qualify certain types of equipment for a beta/gamma environment provided the gamma dose rate during the qualification tests is consistent with the expected beta and gamma dose rates (energy deposition rates) during the LOCA. It appears therefore that a gamma source (only) may be used for qualification testing, provided an analysis or test data indicates that the dose and dose rate produces damage similar to that which could be produced under accident exposure (i.e., combined gamma and beta environment), or a beta and gamma qualification dose and dose rate may be determined separately and the testing may be performed using both a beta and a gamma test source. The staff notes that the research effort is still continuing and that the preliminary findings may change, but until such time as other evidence is presented, the use of either Co-60 or Cs-137 for equipment qualification would seem appropriate.	A.11 Sequential testing requirements are specified in NUREG-0588 and the DOR guidelines. Licensees must follow the test requirements of the applicable document. 1. If the test has been completed without aging in sequence, justification for such a deviation must be submitted. 2. If testing of a given component has been scheduled but not initiated, the test sequence/program should be modified to include aging. 3. Test programs in progress should be evaluated regarding the ability to comply by incorporating aging in the proper sequence. These would then fall in the first or second category. When a failure occurs due to a non-EQ related mechanism, acceptability of analysis to extrapolate the test data would be dependent on several considerations (e.g., the specific function being demonstrated, the failure mechanism, when the failure occurred, etc.), may be very difficult to achieve. If such a failure occurs it may be more prudent to correct the failure and continue with the test.

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2.0	QUALIFICATION METHODS (CONT.)				
2.3	TEST SEQUENCE				
	2.3 <u>Test Sequence</u> (1) The test sequence should conform fully to the guidelines established in Section 6.3.2 of IEEE Std. 323-1974. The test procedures should ensure that the same piece of equipment is used throughout the test sequence, and that the test simulates as closely as practicable the postulated accident environment.	2.3 <u>Test Sequence</u> (1) Justification of the adequacy of the test sequence selected should be provided. (2) The test should simulate as closely as practicable the postulated environment. (3) The test procedures should conform to the guidelines described in Section 5 of IEEE Std. 323-1971. (4) The staff considers that, for vital electrical equipment such as penetrations, connectors, cables, valves and motors, and transmitters located inside containment or exposed to hostile steam environments outside containment, separate effects testing for the most part is not an acceptable qualification method. The testing of such equipment should be conducted in a manner that subjects the same piece of equipment to radiation and the hostile steam environment sequentially.	5.2 <u>Qualification by Type Testing</u> 3. <u>Test Sequence</u> - The component being tested should be exposed to a steam/air environment at elevated temperature, and pressure in the sequence defined for its service conditions. Where radiation is a service condition which is to be considered as part of a type test, it may be applied at any time during the test sequence provided the component does not contain any materials which are known to be susceptible to significant radiation damage at the service condition levels or materials whose susceptibility to radiation damage is not known (see Appendix C). If the component contains any such materials, the radiation dose should be applied prior to or concurrent with exposure to the elevated temperature and pressure steam/air environment. The same test specimen should be used throughout the test sequence for all service conditions the equipment is to be qualified for by type testing. The type test should only be considered valid for the service conditions applied to the same test specimen in the appropriate sequence.	<u>Resolution</u> 68 - (2.3(1)) The implementation of Section 6.3.2(3) of IEEE 323-1974 (or the staff's position) establishes a data base during normal environments which should provide a comparison of the performance characteristics at the more severe environments. The staff agrees with the statement in the standard that if a data base is available from other tests "on <u>identical</u> or essentially similar equipment," then there is no need to repeat a test to establish a redundant set of performance characteristics at a normal environment. However, caution should be taken in using data from other than identical equipment, so that extrapolation of data is indeed valid. When exposing equipment to hostile environments, the same piece of equipment should be used in sequence (see resolution to Comment No. 69). The staff does not agree that Section 2.3(1) is the conflict with Section 6.3.2(3) of IEEE 323-1974 but does recognize that justified exception may also be found acceptable. <u>Resolution</u> 69 - (2.3(4)) Justification for the adequacy of the sequence used should be established and provided as part of the qualification documentation. Exceptions, if justified, may be established and will be evaluated on a case-by-case basis. If the adequacy of the qualification method can not be justified, retesting or equipment replacement may be warranted.	

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2.0	QUALIFICATION METHODS (CONT.)				
2.4	OTHER QUALIFICATION METHODS				
	2.4 <u>Other Qualification Methods</u> Qualification by analysis or operating experience implemented, as described in IEEE Std. 323-1974 and other ancillary standards, may be found acceptable. The adequacy of these methods will be evaluated on the basis of the quality and detail of the information submitted in support of the assumptions made and the specific function and location of the equipment. These methods are most suitable for equipment where testing is precluded by physical size of the equipment being qualified. It is required that, when these methods are employed, some partial type tests on vital components of the equipment be provided in support of these methods.	2.4 <u>Other Qualification Methods</u> Same as Category I (except that IEEE Std. 323-1971 and ancillary standards endorsed at the time the CP SER was issued may be used).	5.3 <u>Qualification by a Combination of Methods (Test, Evaluation, Analysis)</u> As discussed in Section 5.1 above, an item of Class IE equipment may be shown to be qualified for a complete spectrum of service conditions even though it was only type tested for high temperature, pressure and steam. The qualification for service conditions such as radiation and chemical sprays may be demonstrated by analysis (evaluation). In such cases the overall qualification is said to be by a combination of methods. Following are two specific examples of procedures that are considered acceptable. Other similar procedures may also be reviewed and found acceptable on a case by case basis. 1. <u>Radiation Qualification</u> - Some of the earlier type tests performed for operating reactors did not include radiation as a service condition. In these cases the equipment may be shown to be radiation qualified by performing a calculation of the dose expected, taking into account the time the equipment is required to remain functional and its location using the methods described in Appendix B, and analyzing the effect of the calculated dose on the materials used in the equipment (see Appendix C). As a general rule, the time required to remain functional assumed for dose calculations should be at least 1 hour. 2. <u>Chemical Spray Qualification</u> - Components enclosed entirely in corrosion resistant cases (e.g., stainless steel) may be shown to be qualified for a chemical environment by an analysis of the effects of the particular chemicals on the particular enclosure materials. The effects of chemical sprays on the pressure integrity of any gaskets or seals present should be considered in the analysis.		

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3.0	MARGINS				
	3. <u>MARGINS</u> (1) Quantified margins should be applied to the design parameters discussed in Section 1 to assure that the postulated accident conditions have been enveloped during testing. These margins should be applied in addition to any margins (conservatism) applied during the derivation of the specified plant parameters. (2) In lieu of other proposed margins that may be found acceptable, the suggested values indicated in IEEE Std 323-1974, Section 6.3.1.5, should be used as a guide. (Note exceptions stated in Section 1.4.) (3) When the qualification envelope in Appendix C is used, the only required margins are those accounting for the inaccuracies in the test equipment. Sufficient conservatism has already been included to account for uncertainties such as production errors and errors associated with defining satisfactory performance (e.g., when only a small number of units are tested).	3. <u>MARGINS</u> (1) Same as Category I. (2) The margins provided in the design will be evaluated on a case-by-case basis. Factors that should be considered in quantifying margins are (a) the environmental stress levels induced during testing, (b) the duration of the stress, (c) the number of items tested and the number of tests performed in the hostile environment, (d) the performance characteristics of the equipment while subjected to the environmental stresses, and (e) the specified function of the equipment. (3) Same as Category I.	6.0 <u>Margin</u> IEEE Std. 323-1974 defines margin as the difference between the most severe specified service conditions of the plant and the conditions used in type testing to account for normal variations in commercial production of equipment and reasonable errors in defining satisfactory performance. Section 6.3.1.5 of the standard provides suggested factors to be applied to the service conditions to assure adequate margins. The factor applied to the time equipment is required to remain functional is the most significant in terms of the additional confidence in qualification that is achieved by adding margins to service conditions when establishing test environments. For this reason, special consideration was given to the time required to remain functional when the guidelines for Functional Testing and Failure Criteria in Section 5.2 above were established. In addition, all of the guidelines in Section 4.0 for establishing service conditions include conservatisms which assure margins between the service conditions specified and the actual conditions which could realistically be expected in a design basis event. Therefore, if the guidelines in Sections 4.0 and 5.2 are satisfied no separate margin factors are required to be added to the service conditions when specifying test conditions.	<u>Resolution</u> 70 - (3(1)) The staff is in agreement that additional margin need not be added if it can be shown that adequate margin (to account for uncertainties identified in IEEE 323) is already included in the environmental requirements. Although claims are made that these margins are included in the calculated envelopes, experience has shown that these margins may not be adequately quantified to facilitate independent verification. In general qualified margins should be applied to the design parameters discussed in Section 1 to assure that the postulated accident environmental conditions have been enveloped. The margins should (1) account for uncertainties associated with the use of analytical techniques in deriving environmental parameters; (2) account for uncertainties associated with defining satisfactory performance (e.g., when only a small number of units are tested (3) account for variations in the commercial production of the equipment and (4) account for the inaccuracies in the test equipment to assure that the calculated parameters have been enveloped. These margins should be provided in addition to any conservatisms applied during the derivation of the specified plant parameters unless these conservatisms can be quantified and shown to contain sufficient margin. It is the staff's belief that when temperature and pressure conditions are derived using the methods identified in Section 1.1(2) or the qualification envelope in Appendix C is used, or the radiation methodology described in Appendix D is used the only additional margins to be provided are those accounting for the inaccuracies in the test equipment. Sufficient conservatism has already been included to account for the uncertainties identified in (1) through (3) above. <u>Resolution</u> 72 - (3(1)) Qualification documentation should clearly show that the environmental parameters (to which the equipment may be exposed) have been adequately enveloped. If no margin can be claimed per Section 3.2 of the NUREG (Category II), the adequacy of the design is considered questionable. (See also response to Comment No. 7). <u>Resolution</u> 73 - (3(2)) The staff supports the Nuclear Power Engineering Committee position on margins and considers the comment an amplification of the staff positions identified in the NUREG (specifically, Section 3(2) of Category I). <u>Resolution</u> 74 - (3(3)) Margins to account for inaccuracies in the test equipment should factor in the accuracy tolerance of the sensors used to monitor the test conditions (for example, pressure or temperature sensors). These margins should be added to the test profiles to ensure that the calculated environments have been enveloped. For example, if the maximum temperature to be sensed is 300°F and the sensor can be in error by 5°F at that value, then the indicated temperature during the test should not be less than 305°F to ensure that maximum conditions have been simulated. <u>Resolution</u> 75 - (3(3)) Margins should be applied to account for test, production, and analytical uncertainties that are identified in IEEE Standard 323 and NUREG-0588, independent of their design chronology.	A.12 The staff does not require that the nuclear instrumentation and its associated components be environmentally qualified for a LOCA or HELB. The nuclear instrumentation system is used for transient conditions but is not required for a LOCA or HELB. The staff does require that equipment designed to perform its safety-related function within a short time into an event be qualified for a period of at least 1 hour in excess of the time assumed in the accident analysis. The staff has indicated that time is the most significant factor in terms of the margins required to provide an acceptable confidence level that a safety-related function will be completed. Our judgment of at least 1 hour is based on the acceptance of a type test for a single unit and the spectrum of accidents (small and large breaks) bounded by the single test. Also see answer to Question 21.

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3.0	MARGINS (CONT.) (4) Some equipment may be required by the design to only perform its safety function within a short time period into the event (i.e., within seconds or minutes), and, once its function is complete, subsequent failures are shown not to be detrimental to plant safety. Other equipment may not be required to perform a safety function but must not fail within a short time period into the event, and subsequent failures are also shown not to be detrimental to plant safety. Equipment in these categories is required to remain functional in the accident environment for a period of at least 1 hour in excess of the time assumed in the accident analysis. For all other equipment (e.g., post-accident monitoring, recombiners, etc.), the 10 percent time margin identified in Section 6.3.1.5 of IEEE Std. 323-1974 may be used.	(4) Same as Category I.		<u>Resolution</u> 76 - (3(4)) For equipment subjected to hostile environments resulting from pipe breaks, an accepted practice is to qualify that equipment to the most limiting environment (which would envelope the less hostile environments caused by a range of different pipe breaks). Subjecting the equipment to the most severe portion of the hostile environment (maximum pressure, temperature, and radiation) for only a very short time period (seconds or minutes) does not provide adequate assurance that all the environmental service conditions have indeed been enveloped. It is the staff's belief that the additional one hour of demonstrated functional operability for equipment required to operate for only a short period (that is, less than or equal to 10 hours), provides for the most part, the assurance that the equipment will function in any accident environment that can exist during large and small line-break accident scenarios. There may be some designs where less restrictive margins may be justified and found acceptable on a case-by-case basis (see Category II, Section 3(2)). The staff believes, however, that the general requirement of testing for an additional hour is warranted.	

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4.0	AGING 4. AGING (1) Aging effects on all equipment, regardless of its location in the plant, should be considered and included in the qualification program (2) The degrading influences discussed in Sections 6.3.3, 6.3.4 and 6.3.5 of IEEE Std. 323-1974 and the electrical and mechanical stresses associated with cyclic operation of equipment should be considered and included as part of the aging programs. (3) Synergistic effects should be considered in the accelerated aging programs. Investigation should be performed to assure that no known synergistic effects have been identified on materials that are included in the equipment being qualified. Where synergistic effects have been identified, they should be accounted for in the qualification programs. Refer to NUREG/CR-0276 (SAND 78-0799) and NUREG/CR-0401 (SAND 78-1452), "Qualification Testing Evaluation Quarterly Reports," for additional information. (4) The Arrhenius methodology is considered an acceptable method of addressing accelerated aging. Other aging methods that can be supported by type tests will be evaluated on a case-by-case basis. (5) Known material phase changes and reactions should be defined to insure that no known changes occur within the extrapolation limits. (6) The aging acceleration rate used during qualification testing and the basis upon which the rate was established should be described and justified. (7) Periodic surveillance testing under normal service conditions is not considered an acceptable method for on-going qualification, unless the plant design includes provisions for subjecting the equipment to the limiting service environment conditions (specified in Section 3(7) of IEEE Std. 279-1971) during such testing.	4. AGING (1) Qualification programs that are committed to conform to the requirements of IEEE Std. 382-1972 (for valve operators) and IEEE Std. 334-1971 (for motors) should consider the effects of aging. For this equipment, the Category I positions of Section 4 are applicable. (2) For other equipment, the qualification programs should address aging only to the extent that equipment that is composed, in part, of materials susceptible to aging effects should be identified, and a schedule for periodically replacing the equipment and/or materials should be established. During individual case reviews, the staff will require that the effects of aging be accounted for on selected equipment if operating experience or testing indicates that the equipment may exhibit deleterious aging mechanisms.	7.0 Aging Implicit in the staff position in Regulatory Guide 1.89 with regard to backfitting IEEE Std. 323-1974 is the staff's conclusion that the incremental improvement in safety from arbitrarily requiring that a specific qualified life be demonstrated for all Class 1E equipment is not sufficient to justify the expense for plants already constructed and operating. This position does not, however, exclude equipment using materials that have been identified as being susceptible to significant degradation due to thermal and radiation aging. Component maintenance or replacement schedules should include considerations of the specific aging characteristics of the component materials. Ongoing programs should exist at the plant to review surveillance and maintenance records to assure that equipment which is exhibiting age related degradation will be identified and replaced as necessary. Appendix C contains a listing of materials which may be found in nuclear power plants along with an indication of the material susceptibility to thermal and radiation aging.	Resolution 79 - (4(2)) As stated in the position of Section 4.2, the staff has and will continue to identify materials and or equipment that may be susceptible to deleterious aging effects. It is, however, incumbent on the user of the equipment (that is, the utility) to ensure that the equipment that has been identified by the staff and by others as being susceptible to significant degradation because of aging is properly accounted for. Data banks established by owners groups are one way of maintaining current information of specific equipment in use today. Ongoing programs should exist at the plant to review surveillance and maintenance records to ensure that equipment which is exhibiting age-related degradation will be identified and replaced as necessary. Resolution 85 - (4(5)) The use of previous testing to support the claims that conservative extrapolation limits have been implemented in the qualification programs is acceptable, provided the materials used in previous tests are identical or sufficiently similar so that a comparison is valid. The position is general to allow such specific applications. Resolution 86 - (4(6)) For cases where equipment is composed of different material components having different activation energies, and testing each component separately is not practical, the testing of the equipment should be conducted using the most limiting (lowest) activation energy of the components. Resolution 88 - (4(7)) This position applies when the choice of qualification is on-going, in order to extend, verify, or provide a more realistic qualified life. It is the opinion of the staff that component degradation due to aging for the most part may not be readily detectable by visual inspection or testing at only the normal service conditions. However, in the hostile environments this degradation, if significant, should be readily apparent. Resolution 16 - (1,4) With the exceptions noted in Section 4(1) of the NUREG, the staff does not require that a qualified life be established for all Category II equipment. The words "qualified life" may be interpreted as "installed life" for Category II equipment. Resolution 80 - (4(3)) The staff is aware that some equipment important to safety may contain materials whose aging effects from combined environments (applied either concurrently or sequentially) are more severe than the sum of the effects of each environmental parameter applied separately. Identifying the most limiting combination of environmental parameters in order to establish a qualified life through research programs, however, may be a long-term, on-going process. Therefore, in lieu of research programs, the qualification program should: (1) Identify potentially significant synergistic effects through a literature search and account for those effects through testing or analysis when establishing a qualified life, or	

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4.0	AGING (CONT.) (8) Effects of relative humidity need not be considered in the aging of electrical cable insulation. (9) The qualified life of the equipment (and/or component as applicable) and the basis for its selection should be defined. (10) Qualified life should be established on the basis of the severity of the testing performed, the conservatisms employed in the extrapolation of data, the operating history, and on other methods that may be reasonably assumed, coupled with good engineering judgment.			Resolution 68 - (4(3)) (2) Establish through literature search or operating experience the basis for omitting synergistic considerations. For equipment where, for example, significant radiation and temperature environments may be present (and in lieu of contrary information determined through items 1 or 2), the synergistic effects to these parameters should be considered during the simulated aging portion of the overall test sequence. The testing sequence used to age the equipment (or material) should be justified and the basis documented in the qualification report. For equipment where thermal aging evaluation has been conducted prior to issuance of this document on non-irradiated equipment or materials, the adequacy of the assumptions made and the conclusions reached will be evaluated on a case-by-case basis. Other methods designed to address synergisms (such as ongoing surveillance with additional qualification testing) may also be found acceptable and will be evaluated on a case-by-case basis. Resolution 70 - (4(1)) This area is under staff review. Any modifications to the staff positions will be included in the final rulemaking which is planned to be issued to public comment in December 1981. In general the staff does not require, for Category II plants, the same degree of rigor in the proof testing, analysis, and documentation as it does for Category I equipment. Recognizing the limitations in the state of the art in assessing synergistic effects, the position regarding synergisms for Category I is not applicable to Category II plants unless know synergistic effects have been identified on the materials that are in use in these older plants. With the exception noted above (synergisms), the aging positions identified for Category I are applicable for Category II equipment identified in Section 4(1). Resolution 69 - (4(8)) The effects of humidity on equipment should be considered in the qualification program. Justification, however, may be established to limit the testing of selected equipment to the range and the duration of humidity environments expected at a plant site. A literature search of the tests conducted on identical or similar equipment (or materials) or operating experience may be used to establish a basis for not including rigorous humidity testing. As an example, the Sandia Laboratory report SAND 78-0344 (October 1978) on "Aging of Nuclear Power Plant Safety Cables" provides assurance that humidity effects on the cable insulation materials tested is not a significant aging contributor. Therefore, for qualification of equipment using these materials, the aging effects due to humidity may be omitted. The basis for these exemptions, however, should be documented. An NRC-funded research program is presently investigating aging mechanisms due to humidity and is developing methods to qualitatively assess these effects on selected materials (reference NUREG/CR-1466, "Predicting Life Expectancy and Simulating Age of Complex Equipment Using Accelerated Aging Techniques," April 1980). The staff has not, however, endorsed any one specific method of accelerating humidity. At this time, various methods of accelerating humidity effects during the aging portion of the test program or humidity conditioning during a test sequency may be found acceptable.	

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5.0	DOCUMENTATION 5. QUALIFICATION DOCUMENTATION (1) The staff endorses the requirements stated in IEEE Std. 323-1974 that, "The qualification documentation shall verify that each type of electrical equipment is qualified for its application and meets its specified performance requirements. The basis of qualification shall be explained to show the relationship of all facets of proof needed to support adequacy of the complete equipment. Data used to demonstrate the qualification of the equipment shall be pertinent to the application and organized in an auditable form." (2) The guidelines for documentation in IEEE Std. 323-1974 when fully implemented are acceptable. The documentation should include sufficient information to address the required information identified in Appendix E. A certificate of conformance by itself is not acceptable unless it is accompanied by test data and information on the qualification program.	5. QUALIFICATION DOCUMENTATION (1) Same as Category I. (2) Same as Category I, except the guidelines of IEEE Std. 323-1971 may be used.	8.0 Documentation Complete and auditable records must be available for qualification by any of the methods described in Section 5.0 above to be considered valid. These records should describe the qualification method in sufficient detail to verify that all of the guidelines have been satisfied. A simple vendor certification of compliance with a design specification should not be considered adequate.	Resolution 91 - (5(2)) The staff position does not exclude the use of data from tests conducted on similar equipment as long as independent verification of similarity or equivalence can be established. It is incumbent on the applicant to have the necessary documentation to justify the adequacy of using data from similar or equivalent equipment. Any modification to the staff positions will be included in the final rulemaking which is planned to be used for public comment in December 1981.	