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# Guidance for Accident Function Assessment for RISC-3 Applications

## Alternate Treatment to Environmental Qualification for RISC-3 Applications

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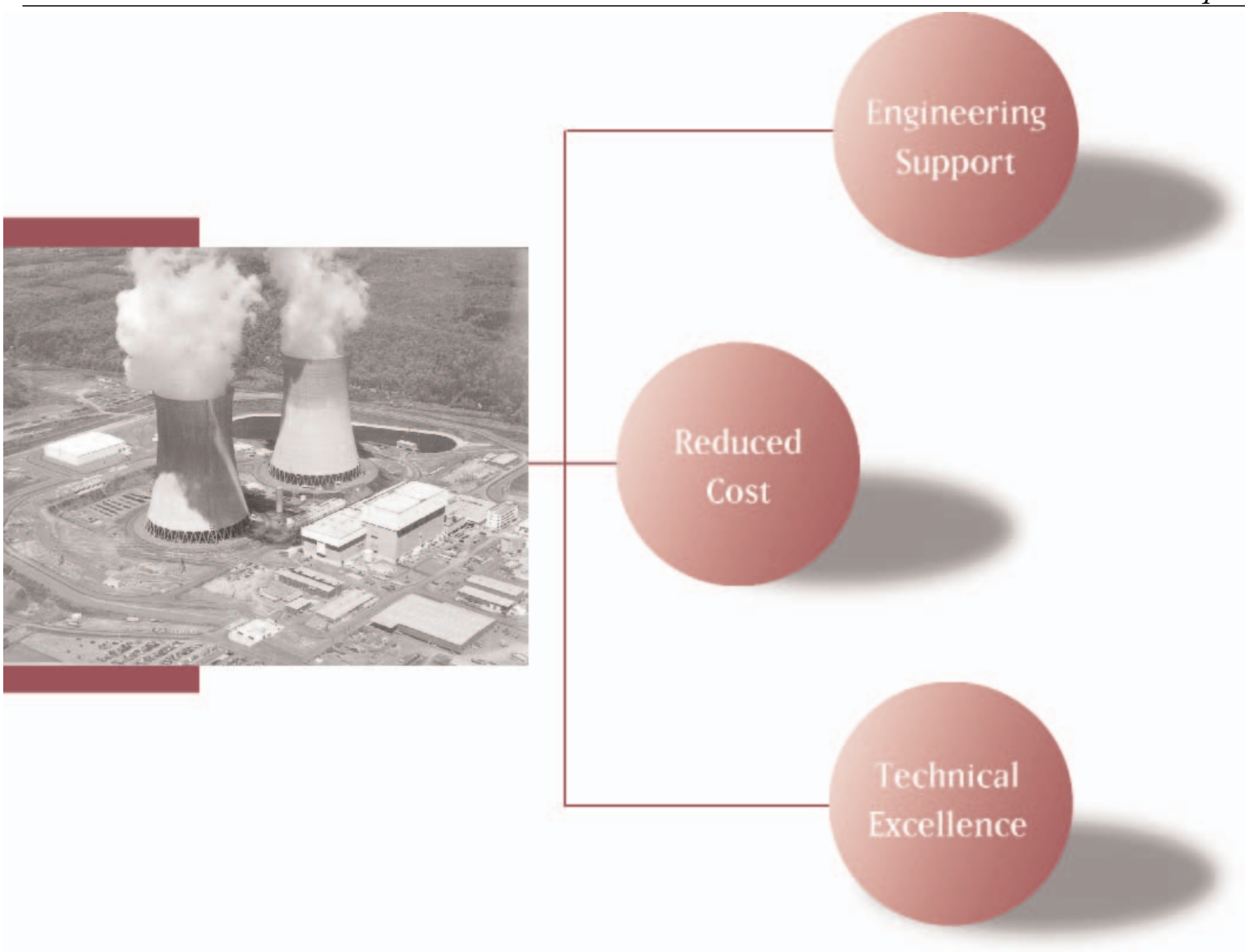

# Guidance for Accident Function Assessment for RISC-3 Applications

## Alternate Treatment to Environmental Qualification for RISC-3 Applications

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# REPORT SUMMARY


This report provides guidance for establishing reasonable confidence that RISC-3 (safety-related, low safety-significance) harsh environment electrical components will perform their design basis accident functions in accordance with the requirements of 10CFR50.69, *Risk-Informed Safety Categorization Process*. Guidance is provided for the continued use of components qualified under 10CFR50.49 requirements, for procuring equivalent replacement components, and for assessing the ability of new component types for RISC-3 applications. Guidance is also provided for the removal of unnecessary conservatism related to replacement, maintenance, calibration, and refurbishment for harsh environment electrical applications that have been categorized as RISC-3.

## Background

10CFR50.69 has been developed to allow utilities to risk-inform the safety classification of structures, systems, and components. When the risk-informed safety class (RISC) has been determined, some electrical components that had been safety related and were located in harsh environments will be categorized as RISC-3: safety related, but having low safety significance. These RISC-3 components have been determined to have little to no effect on mitigating a reactor core melt and an off-site radiation release. 10CFR50.69 eliminates nearly all special treatments and reporting requirements for RISC-3 components and replaces them with alternate treatments commensurate with the component's safety significance. Under 10CFR50.69, the formal requirements of 10CFR50.49, 10CFR21, and 10CFR50 Appendix B do not apply to RISC-3 components and are replaced with activities that provide reasonable confidence that the devices will continue to perform their design basis functional requirements. 10CFR50.69 requires the design basis to be maintained for RISC-3 components. This report describes alternate treatment methods that will provide reasonable confidence that components categorized as RISC-3 will continue to be able to perform their required accident functions.

## Objective

- To provide guidance on the types and level of efforts necessary to establish reasonable confidence that new and replacement RISC-3 components will perform their design basis functions under harsh environment conditions

## Approach

This report describes the basic RISC classification process, the requirements that apply to RISC-3 components, the difference between design basis requirements and other commitments that no longer apply, and how to establish reasonable confidence in the performance of design basis functions. The basic concepts for determining the acceptability of RISC-3 components with

respect to environmental and service conditions are provided in the main body of the report. More detailed methodology and data along with examples of their usage are provided in the appendices.

## EPRI Perspective

Risk-informing the special treatment requirements is intended to focus utility resources on the most safety-significant plant equipment. The implementation of the RISC process is expected to provide significant cost savings without reducing plant safety. The savings are expected from the reduction of special treatments for RISC-3 components. The designation of **safety-related, low safety significance** challenges pre-existing norms. **Safety-related** immediately causes the reader to think of a highly important function that must be performed. However, the added phrase **low safety significance** must be the focus. When low safety significance is the focus, the reader can understand why a reduced level of treatment and reduction of excess conservatisms are satisfactory for RISC-3 applications and why **reasonable confidence** in the performance of accident functions is acceptable. This report provides guidance on how to establish reasonable confidence in the performance of accident function in accordance with 10CFR50.69 for RISC-3 components used in harsh environments.

## Keywords

Accident function assessment
Environmental qualification
Risk-informed safety categorization
RISC-3
Reasonable confidence
Item equivalency

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# 1 INTRODUCTION AND DEFINITIONS OF KEY TERMS

## 1.1 Introduction

10CFR50.69, *Risk-Informed Categorization and Treatment of Structures, Systems, and Components for Nuclear Power Reactors*, allows nuclear plant components to be categorized with respect to safety significance and special treatments to be commensurate with that safety significance [1]. The risk-informed safety class (RISC) categorization process places structures, systems, and components (SSCs) into one of four RISC categories. The category related to this report is RISC-3: safety-related, low safety-significance components. 10CFR50.69 eliminates or reduces many of the special treatments for SSCs categorized as RISC-3. Special treatment requirements are generally very prescriptive and require significant implementation efforts on the part of a licensee. For low safety-significance RISC-3 components, 10CFR50.69 specifies both high-level treatment requirements of inspection and testing as well as corrective action. The implementation burden for these high-level treatment requirements is significantly less than that of the special treatments for safety-related, safety-significant components. This report focuses on safety-related electrical components in harsh environment applications that have been categorized as RISC-3. The special treatment requirements of 10CFR50.49 do not apply to RISC-3 components [2]. Instead, the ability of RISC-3 components to function under design basis conditions will be assessed through a process appropriate to their low safety significance. This report provides guidance on how to assess the environmental ability of equipment with respect to its performance of design basis function under harsh environment conditions.

This section of the report provides an introduction and defines key terms. Section 2 provides background information on the categorization process and the types of activities required for the treatment of RISC-3 components. A key issue with the alternate treatment is that reasonable confidence in the performance of design basis functions must exist. Accordingly, this report defines **reasonable confidence** and helps the reader to focus on design basis requirements. The differences between design basis, licensing basis, and other types of information are also described in Section 2. Section 3 defines **reasonable confidence** and the level of effort necessary to establish reasonable confidence in a component's performance of design basis function. Section 4 indicates the special treatments that no longer apply to establishing the environmental capability of RISC-3 components and then describes what is required for environmental assessment of RISC-3 components. Section 5 provides the introduction to and the techniques that will be used to implement the alternate treatment, an accident function assessment. When the categorization to RISC-3 occurs, the original environmentally qualified equipment will remain in place and its environmental qualification (EQ) will be its **accident function assessment**. As components are replaced with different components, accident function assessments will be developed. Section 6 describes the relaxation of constraints for the RISC-3 components that

formerly were required to be environmentally qualified to a level appropriate to their low safety significance. Several appendices are provided, and they contain information that can be useful in the development of accident function assessments. Appendix H provides examples of accident function assessments.

This report is intended to be used in conjunction with the EPRI report *10CFR50.69 Implementation Guidance for Treatment of Structures, Systems, and Components* (1011234), which provides guidance on the overall treatment of RISC-3 components, including considerations for procurement [3]. In addition, the EPRI report *RISC-3 Seismic Assessment Guidelines* (1009669) provides guidance on seismic assessment of RISC-3 components [4].

## 1.2 Definitions of Key Terms

**Accident function assessment:** An assessment that establishes reasonable confidence that a device will perform its design basis function under the design basis accident environments throughout its service life.

**Accident function:** The design basis function that must be performed under design basis accident conditions.

**Reasonable assurance:** A justifiable level of confidence based on objective and measurable facts, actions, or observations that imply adequacy.

**Reasonable confidence:** A level of confidence based on facts, actions, knowledge, experience, and/or observations that is adequate for the performance of design basis function.

**Risk-informed safety categorization:** A categorization process that places SSCs in one of the following four risk-informed safety categories:

- RISC-1: SSCs that are safety related and perform safety-significant functions.
- RISC-2: SSCs that are non-safety related and perform safety-significant functions.
- RISC-3: SSCs that are safety related and perform low safety-significant functions.
- RISC-4: SSCs that are non-safety related and perform low safety-significant functions.

**Safety-significant function:** A function whose degradation or loss could result in a significant adverse effect on defense in depth, safety margin, or risk [1].

**Service life:** A period of time under a given set of service conditions for which reasonable confidence exists that a RISC-3 component will perform its design basis functions under applicable accident conditions. Replacement of a RISC-3 component should occur at or near the end of service life. Note that for short periods beyond the end of the stated service life, reasonable confidence in performance of design basis function under accident conditions will exist.

**Special treatment requirements:** Prescriptive requirements as to how licensees are to treat SSCs, especially those that are defined as safety related [1].

**Treatment:** Activities, processes, and/or controls that are performed or used in the design, installation, maintenance, and operation of SSCs as a means of:

- Specifying and procuring SSCs that satisfy performance requirements
- Verifying over time that performance is maintained
- Controlling activities that could impact performance
- Providing assessment of and feedback on results to adjust activities as needed to meet desired outcomes

## 1.3 Acronyms

| | |
|---|---|
| ABS | Acrylonitrile butadiene styrene |
| AFA | Accident function assessment |
| ASME | American Society of Mechanical Engineers |
| BWR | Boiling water reactor |
| CDF | Core damage frequency |
| CFR | Code of Federal Regulations |
| CMOS | Complementary metal oxide semiconductor |
| CSPE | Chlorosulfonated polyethylene |
| DAP | Diallyl phthalate |
| EPDM | Ethylene propylene diene monomer |
| EPR | Ethylene propylene rubber |
| EQ | Environmental qualification |
| FMEA | Failure modes and effects analysis |
| GP | General purpose |
| HELB | High-energy line break |
| HVAC | Heating, ventilation, and air conditioning |

| | |
|---|---|
| IDP | Integrated decision-making panel |
| IEEE | Institute of Electrical and Electronics Engineers |
| LED | Light-emitting diode |
| LERF | Large early release frequency |
| LOCA | Loss-of-coolant accident |
| MCCB | Molded-case circuit breaker |
| MIL SPEC | Military specification |
| MOS | Metal oxide semiconductor |
| MOV | Motor-operated valve |
| MSIV | Main steam isolation valve |
| MSLB | Main steam line break |
| NEI | Nuclear Energy Institute |
| NEMA | National Electrical Manufacturers Association |
| NPT | National Pipe Thread |
| NRC | U.S. Nuclear Regulatory Commission |
| PEEK | Polyetheretherketone |
| PPS | Polyphenylene sulfide |
| PRA | Probabilistic risk assessment |
| PVC | Polyvinyl chloride |
| PWR | Pressurized water reactor |
| RISC | Risk-informed safety categorization |
| RTD | Resistance temperature detector |
| SBO | Station blackout |

| | |
|---|---|
| SCR | Silicon-controlled rectifier |
| SOV | Solenoid-operated valve |
| SSC | Structures, systems, and components |
| Std | Standard |
| STP | South Texas Project Company |
| TERI | Technical evaluation of replacement items |
| TID | Total integrated dose |
| TR | Technical report |
| UL | Underwriters Laboratories |
| UFSAR | Updated final safety analysis report |
| XLPE | Cross-linked polyethylene |

## 1.4 Conversion Factors

Table 1-1 presents conversion factors used to convert values between English and Standard International units.

**Table 1-1**
**Conversion Factors Used in This Report**

| Parameter | English to Standard International Units |
|---|---|
| Energy | 1 hp = 745.7 watts |
| Length | 1 in. = 25.4 mm |
| Pressure | Pa = pascals<br><br>1 psia = pound per square inch absolute<br>= 6894.76 Pa psig<br>= pound per square inch gauge<br>= psia measurement - 14.7 psia<br><br>psig to Pa = (6894.76 Pa/psig) + 101325 Pa |
| Radiation | 1 rad = 0.01 grays |
| Temperature | °F = (°C x 9/5) + 32<br>°F = 1.8 (°C) + 32<br>°C = (°F - 32) x 5/9 |

# 2 BACKGROUND

## 2.1 Regulatory History

The NRC has established a set of regulatory requirements for commercial nuclear reactors intended to ensure that a reactor facility does not impose an undue risk to the health and safety of the public. The current NRC regulations are largely based on a deterministic approach. Requirements were devised on the basis of a defined and analyzed set of events known as *design basis events*. This deterministic approach has employed the use of safety margins, accident analysis, and a defense-in-depth philosophy. Since the development of the original regulations, a significant body of operating experience has accrued. Using these data, performance of probabilistic risk assessment (PRA) has enabled a better understanding of the significance of systems and components to reactor safety. This improved state of knowledge is the basis for 10CFR50.69.

10CFR50.69 allows licensees to voluntarily adopt alternate requirements to certain existing requirements in 10CFR Parts 21 and 50 and Part 100 Appendix A. When a licensee adopts 10CFR50.69, the licensee can categorize structures, systems, and components (SSCs) with respect to safety significance on a system-by-system basis. The entire plant does not need to be categorized. Individual systems in the plant can be categorized, and other systems can remain under the original licensing basis. Under the 10CFR50.69 process, the high-level treatment requirements[1] are applied commensurate with the safety significance of the components after the categorization has been performed.

## 2.2 Risk-Informed Safety Categorization

10CFR50.69 allows a licensee to categorize SSCs with respect to safety significance and to apply treatments commensurate with the SSC safety significance. Treatments are activities, processes, and controls that are performed or used in the design, installation, maintenance, and operation of SSCs as a means of providing assurance that an SSC will perform its specified functions.

[1] Special treatment requirements are current NRC requirements imposed on SSCs that go beyond industry-established (industrial) controls and measures for equipment classified as commercial grade and are intended to provide reasonable assurance that the equipment is capable of meeting its design basis functional requirements under design basis conditions. These additional special treatment requirements include design considerations, qualification, change control, documentation, reporting, maintenance, testing, surveillance, and quality assurance requirements.

10CFR50.69(c)(1) requires the use of a robust categorization process that includes:

- Consideration of results and insights from the plant-specific PRA model
- Determination of functional importance using an integrated systematic process for addressing initiating events, SSC interactions, and plant operating modes, including components not modeled in the plant-specific PRA
- Maintenance of the defense-in-depth philosophy
- Evaluations that provide reasonable confidence that, for SSCs categorized as RISC-3, sufficient safety margins are maintained and any potential increases in core damage frequency (CDF) and large early release frequency (LERF) permitted by implementation of 10CFR50.69(b)(1) and 10CFR50.69(d)(2) are small
- Performance of the categorization for entire systems and structures, not selected components within a system or structure

10CFR50.69(c)(2) states that the categorizations must be performed by an integrated decision-making panel (IDP) staffed with expert, plant-knowledgeable members whose expertise includes—at a minimum—PRA, safety analysis, plant operation, design engineering, and system engineering. NRC Regulatory Guide 1.201 [5], which accompanies the rule, states that the guidance of NEI-00-04 *10CFR50.69 Categorization Guide* [6] is an acceptable approach for the categorization process. The categorization process results in four categories as illustrated in Figure 2-1:

- RISC-1: Safety-related SSCs that perform safety-significant functions
- RISC-2: Non-safety-related SSCs that perform safety-significant functions
- RISC-3: Safety-related SSCs that perform low safety-significant functions
- RISC-4: Non-safety-related SSCs that perform low safety-significant functions

10CFR50.69 does not replace the existing safety-related and non-safety-related classifications. Rather, 10CFR50.69 divides each of these classifications into two subcategories based on high or low safety significance. The 10CFR50.69 categorizations scheme is depicted in Figure 2-1.

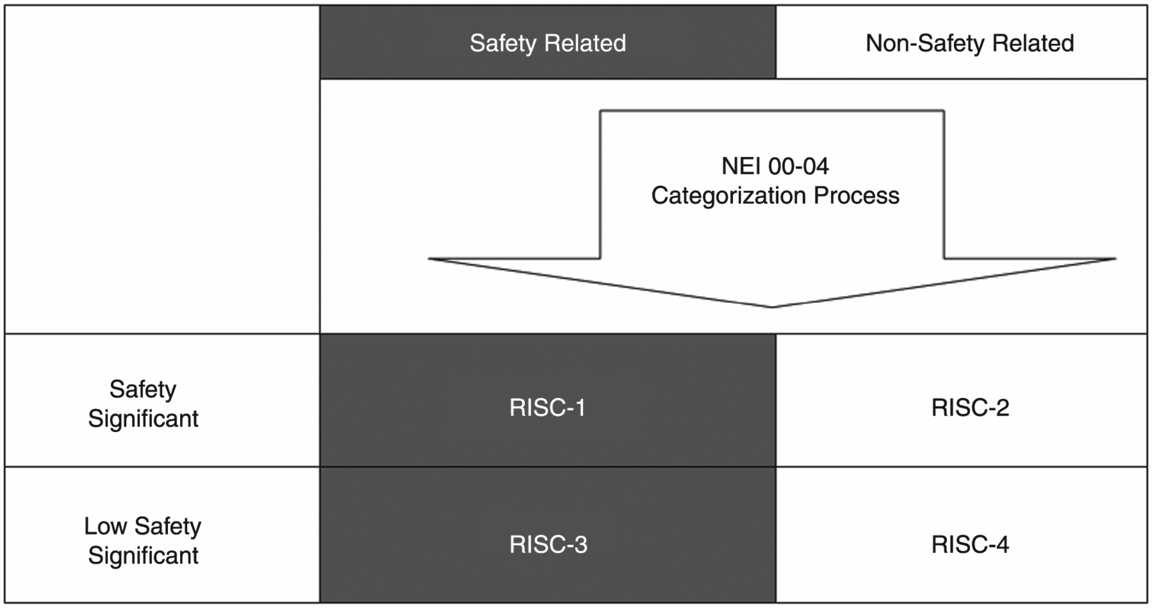


**Figure 2-1**
**Risk-Informed Safety Classifications**

The 10CFR50.69 categorization process determines that some safety-related SSCs are safety significant and designates them as RISC-1. Other safety-related SSCs will be found to have low safety significance, and these will be categorized as RISC-3 SSCs. Likewise, some non-safety-related SSCs will be categorized as safety significant (RISC-2), and the remainder will be low or no safety significant and will be categorized as RISC-4 SSCs. Safety-related SSCs can be categorized only as RISC-1 or RISC-3, and non-safety-related SSCs, including the **important-to-safety** SSCs, can be categorized only as RISC-2 or RISC-4.

## 2.3 Special Treatment Requirements

One element of the NRC's defense-in-depth approach has been the imposition of special treatment requirements on SSCs that are safety related in order to provide a high level of confidence that the SSCs will function during and after the postulated design basis conditions. In regulatory language, this high level of confidence is denoted by the term *reasonable assurance*. Special treatment requirements are imposed on nuclear reactor applicants and licensees through a variety of regulations that have been promulgated since the 1960s. The new 10CFR50.69 uses the term *reasonable confidence* to describe the expected performance of safety-related SSCs having low safety significance with respect to core damage frequency and large early release frequency.

The traditional deterministic approach toward special treatment of SSCs requires that the licensee include and evaluate all safety systems capable of preventing and/or mitigating the consequences of the prescribed design basis events (DBEs) to protect public health and safety. Those SSCs necessary to mitigate DBEs were defined as safety related and were the subject of many specific regulatory requirements designed to ensure that they were of very high quality and reliability, and they had the capability to perform during and after postulated design basis

conditions. These prescriptive requirements are referred to as *special treatment requirements*. They were developed to provide assurance that safety-related SSCs will perform their function under design basis service conditions, including seismic events and accident environments, throughout their service life. The special treatments applied to safety-related SSCs were not adjustable to the relative safety significance.

If a licensee chooses to implement risk-informed safety categorization under 10CFR50.69, RISC-1 components remain under the traditional requirements of 10CFR50, and the special treatments apply to them. RISC-2 components (those that are non-safety related, but are safety significant) will be assessed to ensure that the selected treatments support the key assumptions in the categorization process that relate to their assumed performance. RISC-4 components (those that are non-safety related and have low safety significance) will be treated as traditionally non-safety-related components. RISC-3 is the category of components in which the burden of special treatment can be reduced and replaced with a level of treatment commensurate with the component's low safety significance.

## 2.4 Design Bases Requirements

Although 10CFR50.69 eliminates special treatments for RISC-3 components, 10CFR50.69(d)(2) requires licensees to have reasonable confidence that RISC-3 components are capable of performing their safety-related function under design basis conditions throughout their service life. Two important concepts rest in this subsection of 10CFR50.69: reasonable confidence and the use of design basis conditions.

Design basis conditions are often less restrictive than the licensing basis conditions used to verify the adequacy of EQ as required by 10CFR50.49 and its predecessors. Care must be taken to differentiate between design bases, licensing bases, final safety analysis report statements, and supporting design information.

Many of the environments used in EQ activities under 10CFR50.49 are licensing basis requirements or supporting design information rather than design basis requirements. The licensing basis requirements, such as an enveloping inside-containment profile[2], may be more conservative than need be considered for assessing the capability of a RISC-3 component with respect to its ability to withstand environments and service conditions and should not be used.

Using actual profiles for accidents rather than the enveloping profiles generally used in 10CFR50.49 EQ will eliminate conservatisms that are not required to provide reasonable confidence in the performance of design basis functions. Appendix C describes the means for identifying the required design basis for RISC-3 components to provide the required but less restrictive environments and service conditions for the alternate treatment to EQ.

[2] An enveloping profile is part of the EQ licensing basis if there is a specific utility commitment to the NRC regarding its use.

Formal guidance on what constitutes design basis information is contained in NEI 97-04 Appendix B (November 2000)[3] [7]. 10CFR50 *Domestic Licensing of Production and Utilization Facilities*, Section 50.2, contains the high-level definition of the term *design bases*. The NRC staff and the nuclear utility industry have developed additional guidance for implementing this definition. The Nuclear Energy Institute (NEI) has developed a guideline for design bases determination: NEI 97-04, *Design Basis Program Guidelines*. The NRC issued Regulatory Guide 1.186, *Guidance and Examples for Identifying 10CFR50.2 Design Bases*, in December 2000 [8].

## 2.5 NEI 97-04 Appendix B

NEI developed guidelines within NEI 97-04 for determining the boundaries between design basis, licensing basis, supporting design information, and updated final safety analysis report (UFSAR) information. The basic differences between these types of information are shown in Figure 2-2, which depicts the design basis commitments to be a subset of the information contained in the UFSAR and separate from supporting design information. NEI 97-04 Appendix B gives specific guidance for clarifying the distinction between the design bases and the supporting design information.

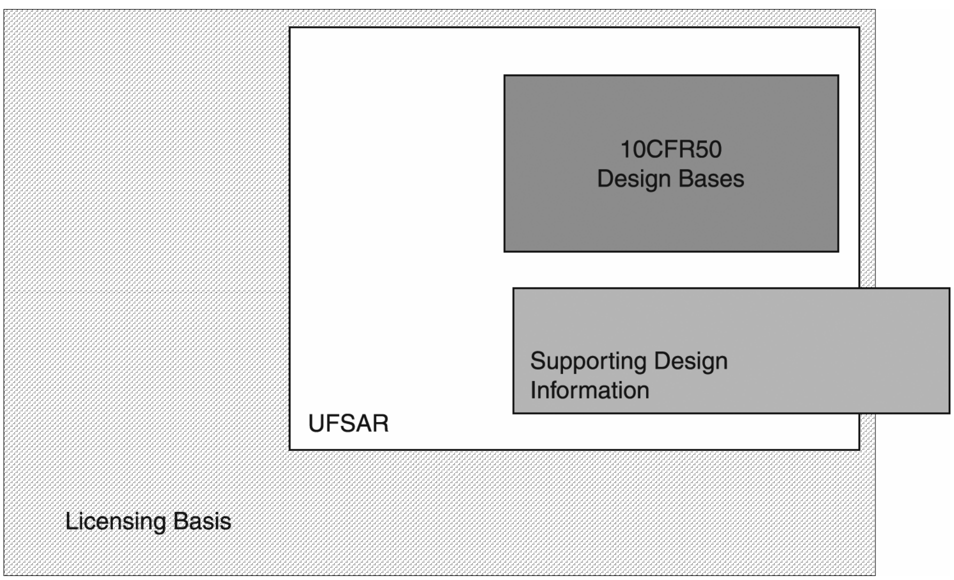


**Figure 2-2**
**Design Basis Determination**

[3] NEI 97-04 Appendix B (November 2000) is contained in Revision 1 to NEI 97-04, which is dated February 2001.

## 2.6 Accident Function Assessments and the Engineering Change Process

This report uses the term *accident function assessment* (AFA) to describe the alternate treatment that will be used for RISC-3 components to replace the EQ special treatment requirements as defined in 10CFR50.49. An *accident function assessment* is an assessment that establishes reasonable confidence that a device will perform its design basis function under the design basis accident environments throughout its service life. An AFA is commensurate in depth of detail and level of assessment with the low safety significance of RISC-3 components. The AFA is part of the alternate treatment required by 10CFR50.69 to provide reasonable confidence that RISC-3 SSCs remain capable of performing their safety-related functions under design basis conditions, including seismic conditions and environmental conditions and effects throughout their service life. The data are presented in the AFA to provide reasonable confidence that the RISC-3 component will function adequately under design basis accident environments. If a component is covered by an existing qualification report, the qualification report can be used as the AFA with no further effort required. There is no reason to generate an AFA if an EQ report and assessment file exist. If a RISC-3 component is replaced with a different type of component, an AFA will be generated to cover environmental concerns related to accident function and normal operation.

Figure 2-3 shows the process for determining the appropriate action to take when replacing a RISC-3 component or implementing a design change. Noncontrolled equipment[4] and mild environment safety-related equipment are not in the scope of 10CFR50.49 and accordingly are not subject to an AFA. For RISC-3 replacement items that are identical to the RISC-3 item being replaced, an AFA or EQ exists, and no additional AFA is required.

Figure 2-3 differentiates between component (that is, item) and subcomponent changes. If a component is replaced with a component that is not identical, either an equivalency assessment or an AFA should be developed. Because relatively small differences in design can affect the ability of a component to function under a harsh environment, the use of an equivalency evaluation may not be sufficient to assess differences in environmental capability. An equivalency evaluation may be used for evaluating differences in subcomponents of components that had a pre-existing EQ or AFA. In these cases, a new AFA need not be generated. However, for components of design that is different from the original, the development of a new AFA rather than the use of an equivalency evaluation is recommended. This does not mean that the new AFA cannot be partially based on an existing AFA or the original qualification, rather, that an equivalency evaluation alone may not be sufficient to provide reasonable confidence in a component's performance of accident function under accident environment conditions. For example, an AFA should be prepared if a transmitter based on a capacitive sensor is being replaced by a transmitter with a force balance mechanism. An AFA would not be needed if the seal gasket for the cover of a transmitter were being replaced by an alternate material. In that

[4] According to the EPRI report *Guidelines for Optimizing the Engineering Change Process for Nuclear Power Plants* (TR-103586), noncontrolled plant equipment consists of SSCs that are not safety related or whose functions impact safety analysis, or other SSCs that are subject to special consideration based on management discretion (for example, considerations given to licensing basis, the Maintenance Rule, personnel safety, availability, and commercial risk).

case, an equivalency evaluation would suffice. Figure 2-3 applies to considerations for environmental conditions for RISC-3 components. For seismic considerations and the other alternate treatment issues for RISC-3 components, an equivalency evaluation can be used to assess replacement devices that have different designs but have similar mass, size, and supports (see the EPRI report *RISC-3 Seismic Assessment Guidelines* [1009669]) [4]. The development of an AFA is described in Section 5, "Accident Function Assessment."

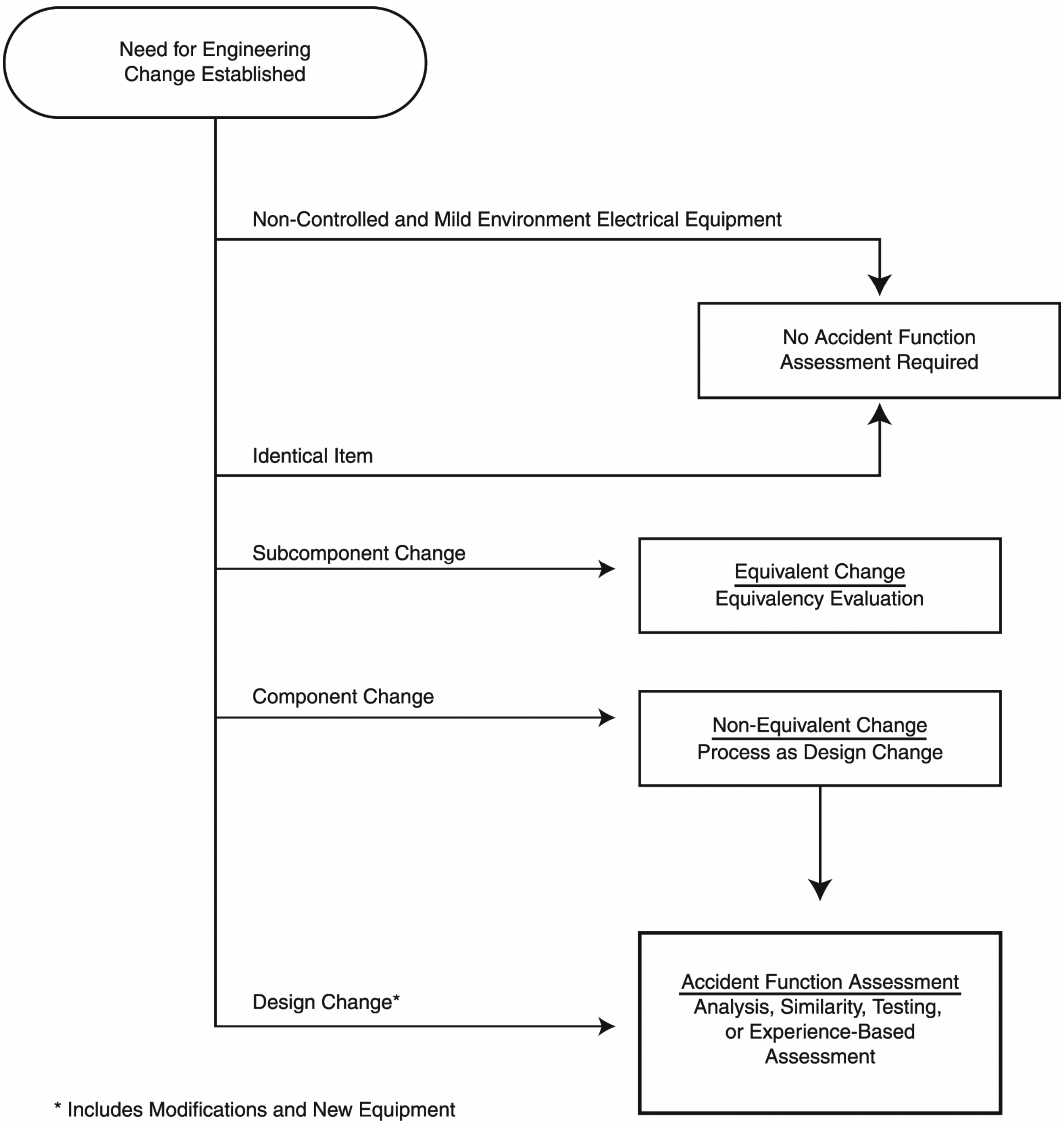


**Figure 2-3**
**Process for Considering an Engineering Change for Environmental Considerations**

# 3
# REASONABLE CONFIDENCE

## 3.1 Definition of Reasonable Confidence

10CFR50.69 requires **reasonable confidence** that RISC-3 components will perform their design basis function. This is the first use of the **reasonable confidence** concept. For the purposes of this report, *reasonable confidence* is defined as:

> A level of confidence based on facts, actions, knowledge, experience, and/or observations that is adequate for performance of design basis function.

This definition is derived from the definition of reasonable assurance that applies to the original term, **safety related**, and which has been defined as:

> A justifiable level of confidence based on objective and measurable facts, actions, or observations, which infer adequacy [9].

10CFR50.34(a)(3)(iii) requires the safety analysis report to provide "Information . . . sufficient to provide **reasonable assurance** that the final design will conform to the design bases with adequate margin for safety." 10CFR50.57(a)(3) on issuance of an operating license states that a license may be issued if "there is **reasonable assurance** that the activities authorized by the operating license can be conducted without endangering the health and safety of the public and that such activities will be conducted in compliance with the regulations" of 10CFR50. **Reasonable assurance** as used in these contexts implies a highly formal process (objective and measurable) with activities performed under the control of a quality assurance program.

The definition of **reasonable confidence** implies a lesser degree of formality and rigor. This definition is consistent with the NRC statement published with 10CFR50.69: "In implementing the rule requirements, licensees will need to obtain data or information sufficient to make a technical judgment that RISC-3 SSCs will remain capable of performing their safety-related functions under design basis conditions" [1]. 10CFR50.69 directly states that a quality assurance program is not required in the performance of activities related to RISC-3 components. Confidence is provided by facts, actions, knowledge, experience, and/or observations and does not necessarily rely on quality assurance programs, regulatory documents, or standards.

## 3.2 Rigor in Engineering and Procurement Efforts for RISC-3 Components

In this report, it is assumed that good engineering practices will be used in determining the ability of a component to function under design basis accident conditions. Good engineering practice entails identifying sufficient information concerning the ability of the device to withstand applicable thermal, radiation, and steam conditions and function adequately. Discussions with a manufacturer’s application engineer, operating experience, catalog information, materials data, and other sources of information can be used as the basis for determining adequacy. Good engineering practice requires the development of an adequate design and configuration of devices that can perform the required function under design basis conditions. However, good engineering practice does not require that a specific process or specific type or style of documentation be used.

# 4 REQUIREMENTS FOR ALTERNATE TREATMENTS FOR RISC-3 COMPONENTS

## 4.1 Eliminated Special Treatment Requirements

10CFR50.69 allows alternate treatments to be used in place of many special treatment requirements for RISC-3 SSCs. This report concentrates on the alternate treatment for EQ.

With respect to harsh environment applications, RISC-3 SSCs are removed from the scope of the following regulations:[5]

- 10CFR21 (reporting requirements)
- 10CFR50.49 (EQ requirements)
- 10CFR50.55(e) (event reporting)
- 10CFR50.55(a)(h) (electrical component quality and qualification requirements in Sections 4.3 and 4.4 of IEEE 279 and in Sections 5.3 and 5.4 of IEEE 603-1991)
- 10CFR50.72 (notification requirements)
- 10CFR50.73 (licensee event reports)
- 10CFR50 Appendix B (quality requirements)

For the development of an alternate treatment for EQ for RISC-3 components, elimination of the requirements of 10CFR21, 10CFR50.49, and 10CFR50 Appendix B are the most significant items in this list.

[5] See EPRI report 1011234 for a complete list of special treatments replaced by 10CFR50.69 for RISC-3 SCCs [3].

## 4.2 Alternate Treatment Requirements

In place of these eliminated special treatments, 10CFR50.69(d) identifies alternate treatment requirements. 10CFR50.69(d), *Alternate Treatment Requirements*, states:

(2) RISC-3 SSCs. The licensee or applicant shall ensure with reasonable confidence that RISC-3 SSCs remain capable of performing their safety-related functions under design basis conditions, including seismic conditions and environmental conditions and effects through their service life. The treatment of RISC-3 SSCs must be consistent with the categorization process. Inspection and testing, and corrective action shall be provided for RISC-3 SSCs.

(i) Inspection and testing. Inspection and testing activities must be conducted to determine that RISC-3 SSCs will remain capable of performing their safety-related functions under design basis conditions; and

(ii) Corrective action. Conditions that would prevent a RISC-3 SSC from performing its safety-related functions under design basis conditions must be corrected in a timely manner.

This implies that the SSCs (components[6]) must be capable of functioning under the applicable accident environment whether new or aged. Paragraph (i) does not imply that the EQ alternate treatment itself must cover or include inspection and testing requirements for RISC-3 components. Consideration of inspection, maintenance, testing, and surveillance is covered by the overall plant activities for RISC-3 components, not just during the development of the accident function assessment. In other words, the development of an accident function assessment for a RISC-3 component may or may not result in a requirement for inspection, maintenance, testing, or surveillance activities. If the AFA determined that such an activity were required to support accident functions, it would become a requirement for use of the RISC-3 component. It should be noted that considerations beyond the assessment of environmental capabilities of RISC-3 components can generate the need for inspection, maintenance, testing, or surveillance. The development of such requirements are not part of the accident function assessment, and such considerations are beyond the scope of this report.

The corrective action required by 10CFR50.69(d)(2)(ii) is an additional support to the establishment and maintenance of reasonable confidence in the capability of RISC-3 components to perform their accident functions. Should an in-service failure occur, the corrective action process will identify the cause of the failure, and the basis of the RISC-3 accident function will be reevaluated as appropriate. If the failure is caused by a factor not related to aging or accident function capability (for example, the device failed because it was exposed to an abnormal condition that has been corrected), no change to the accident function assessment would be necessary. However, if the device failed because of unexpected aging or conditions that would be

[6] While 10CFR50.69 uses the term SSC, environmental qualification is concerned only with electrical components. Accordingly, rather than using SSC, which refers simultaneously to systems, structures, and components, this report uses “component” because the report covers only components.

present under accident conditions in which it was required to function, the accident function assessment would need to be changed to cause the device to be modified, its service life to be shortened, or modified in some other way to compensate for the cause of failure. Under 10CFR50.69(d)(2)(ii), corrective action is needed for plant conditions that are inconsistent with the accident function assessment. Such conditions might include installation (for example, finding that no conduit seals have been installed but that the AFA specifies their use) or revised accident conditions (for example, revised peak loss-of-coolant accident [LOCA] conditions are more severe than those considered in the AFA). In this regard, it is important to recognize that *timely* is directly related to safety significance and that RISC-3 components have low safety significance.

# 5 ACCIDENT FUNCTION ASSESSMENT

## 5.1 Introduction

An accident function assessment is the alternate treatment that replaces EQ for RISC-3 components. An *accident function assessment* is:

> An assessment that establishes reasonable confidence that a device will perform its design basis function under the design basis accident environments throughout its service life.

AFAs are performed to establish reasonable confidence that RISC-3 electrical components can perform their safety-related functions under design basis, harsh environmental conditions throughout their service life.

An accident function assessment compares the effects of environmental conditions—including service conditions—of normal and accident service to the ability of a component to function. The effects of operating cycles, temperature, radiation, steam, and spray (as applicable) are considered with respect to component capability. There are no prescriptive rules for performing an AFA, and any source of credible information can be used, including the following:

- Manufacturer's component specifications and ratings
- Separate effects tests
- Analysis
- Operating history from inside or outside the nuclear industry
- Reports on related but not necessarily identical components

Guidance on the development of AFAs is provided in this section. Examples of AFAs are provided in Appendix H, and subcomponent sensitivities to environments are provided in Appendix G.

## 5.2 Mild Environment and RISC-3

This report is based on the premise that the definition of mild environment from 10CFR50.49 does not change when applied to RISC-3. 10CFR50.49 defines a *mild environment* as an "environment that would at no time be significantly more severe than the environment that would occur during normal plant operation, including anticipated operational occurrences." However, licensees are still obligated under 10CFR50.69 to determine that **all** RISC-3 SSCs

remain capable of performing their safety-related functions under design basis conditions, including seismic conditions, environmental conditions, and effects throughout their service life. For mild environment equipment, this effort would typically be part of the equipment selection or design change processes. For RISC-3 components located in mild environments, no accident function assessment is necessary—just as 10CFR50.49 requirements do not apply to mild environment components. An AFA is needed only for harsh environment components.

## 5.3 Relationship of Accident Function Assessments, Existing Qualification Documentation, and Equivalency Evaluations

For currently operating plants, harsh environment electrical components categorized as RISC-3 will have been qualified in accordance with 10CFR50.49 or its predecessors. Immediately upon a component's categorization as a RISC-3 component, an AFA does not need to be generated. An existing EQ is more than adequate to provide reasonable confidence in the performance of design basis function under accident conditions. As long as the installed component or replacement components are identical to the component from the original qualification, no AFA needs to be generated.

However, if a replacement component is identical to the originally qualified device, an AFA may need to be prepared. As indicated in Figure 2-3, if a component is replaced with a component that is not identical, either an equivalency assessment or an accident function assessment will be developed. Because relatively small differences in design can affect the environmental capabilities of a component under harsh conditions, further guidance is necessary to indicate when equivalency with respect to environmental capability can be established without the need for an AFA. An equivalency evaluation can be used for evaluating differences in subcomponents of components that had a pre-existing EQ or AFA. In these cases, a new AFA need not be generated. However, for components of design different from the original, the development of an AFA rather than the use of an equivalency evaluation is recommended. This does not mean that the AFA cannot be partially based on the original qualification, rather, that an equivalency evaluation alone may not be sufficient to provide reasonable confidence in the performance of accident function. For example, an AFA would be required if a transmitter based on a capacitive sensor is being replaced by a transmitter with a force balance mechanism. An AFA would not be needed if the seal gasket for the cover of a transmitter were being replaced by an alternate material. In that case, an equivalency evaluation would suffice. Figure 2-3 shows the additional consideration.

An existing EQ is a significant aid when identifying a suitable replacement and establishing **reasonable confidence** in the replacement component performance of design basis accident functions. The EQ component and the testing or analysis that was used to qualify it provide a basis of comparison when components are replaced with components that are not identical. The EQ component design contains the basic attributes that are required to withstand an accident environment (for example, specific materials and sealed housing). Therefore, there is an established basis for comparison of the replacement component. This comparison should recognize that the existing component may be significantly overqualified for the application because it was qualified to worst-case conditions, and an adequate but less hardy and less expensive component may be satisfactory for function under the constraints of **reasonable**

**confidence**. In such cases, the commercial version of the environmentally qualified device or a similar component from another manufacturer may be fully acceptable based on an equivalency analysis or an AFA.

## 5.4 Effects of Normal Aging and Synergisms

Normal aging and synergisms are important only if the combined effects of aging and accident conditions approach the limits of a component to absorb the environmental stresses and continue to perform its function. If the normal conditions and accident conditions are benign, there will be no concern for most industrial components with regard to aging and synergisms. If accident conditions are severe and the effects of the accident severely degrade the materials of a component, the severity of normal environments must be considered. If the normal conditions are benign (for example, low normal temperatures and a de-energized component), a service life constraint is likely to be unnecessary. If the normal conditions are severe (high normal temperature and/or radiation dose rate), a service life limit may be necessary, and synergisms may be important. A service life for a RISC-3 component is similar to qualified life for a 10CFR50.49 component; however, the derivation of service life and its rigidity are less constraining that those of qualified life. Although an Arrhenius calculation can be used to determine service life, other means—such as experience with non-safety components, manufacturers' information, and literature searches—can be used as the basis. The low safety significance of a RISC-3 component allows more latitude in replacement of a component at the end of its service life. For example, reasonable confidence in the performance of function would still exist if a component were used for a short time beyond the end of its service life to allow plant operation until the start of the next refueling period.

A basic understanding of the severity of the normal environment, the capability of the RISC-3 component, and its application may allow normal aging to be eliminated as a concern. For example, devices rated for continuous operation in an ambient temperature of 40–50°C will age very slowly at 30°C. Aging can be a concern if equipment locations have temperatures at or above the rated temperature of the component, and further consideration of aging would be appropriate. A device with an internal temperature rise from operation would have little aging concern if it is normally de-energized, but it would probably have a service life limit if it were continuously energized. As part of the development of an AFA, the importance of aging is considered. For some components, normal aging is unimportant, and for others, the effect must be considered. Certainly, no concern for aging would occur for a component such as a phenolic terminal block with a 150°C rating when it is used in a 40°C environment. But a continuously energized solenoid coil would produce heat that could cause an aging concern. The treatment of this concern, however, can be as simple as determining a life limit based on experience with similar applications rather than having a formal aging analysis.

For 10CFR50.49 applications, **known synergisms** have been a concern when considering applications that experience significant thermal and radiation aging as might occur for inside-containment applications. The synergistic effects concerns in 10CFR50.49 are related to accelerated aging that simulates normal environments. Synergisms are of concern in relation to simulation of normal aging and not in relation to simulation of accident exposures. Synergisms

that have been experienced in accelerated aging research tests are related to rate and order[7] of accelerated thermal and radiation aging. Most accelerated laboratory aging that has been used in EQ has been performed at very elevated temperatures and high dose rates. Simultaneous thermal and radiation acceleration is not currently possible in commercial laboratories. Accordingly, thermal and radiation aging is done sequentially. For some materials, different degrees of aging result when the order of laboratory aging is reversed. In some cases, order effects are different for individual materials in the same generic grouping, such as ethylene propylene rubbers (EPRs). However, normal aging is different from laboratory aging in two ways: 1) normal aging is always simultaneous, and 2) normal doses are generally at least an order of magnitude smaller than were assumed in the EQ research where sequence issues were identified. Synergisms are of concern in relation to simulation of normal aging, not in relation to simulation of accident exposures. The normal aging, 40-year dose in nearly all nuclear applications is well below 5 Mrd, while 50 Mrd was assumed in EQ research. With actual doses below 5 Mrd, few if any of the synergisms are of any practical importance. These rate and order synergisms do not exist or are inconsequential when the total normal dose is low, such as for that occurring outside containment, where 40-year normal doses are typically well below 1 Mrd. The total doses (normal plus accident) received outside containment are lower than the dose where synergisms of significance have been observed.

For inside-containment applications, most applications will not have aging doses that exceed 5 Mrd where synergisms might be observed[8]. Existing EQ evaluations have already considered synergisms and could be referenced if an aging dose in excess of 5 Mrd is expected. Unless the inside-containment dose is high and the component is not related to an existing EQ evaluation, synergisms are unlikely to be important for RISC-3 components in establishing reasonable confidence in the performance of accident function.

The key to considering aging with respect to reasonable confidence in the performance of accident function is to select components with thermal and radiation capabilities suitable for the expected temperature and radiation dose. For components that will be exposed to high temperature and radiation levels, higher capability materials should be used. See Appendix A, "Material Capabilities Information," for guidance.

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[7] Thermal exposure before radiation exposure versus simultaneous exposure or radiation before thermal exposure.

[8] Figure 13.5 in EPRI report *Nuclear Power Plant Equipment Qualification Reference Manual* (TR-100516) shows the nature of dose rate effects synergisms [13]. While different dose rates for doses above 5 Mrd can cause significant differences in material degradation, the effects of 5 Mrd or less cause insufficient damage to be of concern to functionality no matter what dose is used. Similarly, Section 2.3 of *Status Report on Equipment Qualification Issues Research and Resolution Reference*, which summarizes all of the research on synergisms by Sandia National Laboratories, shows the same thing: for a low total dose (for example, <5 Mrd), dose rate effects are inconsequential [21].

## 5.5 Documentation and Configuration Control

After components are categorized as RISC-3, utilities will maintain a RISC-1 (safety related, safety significant) and RISC-3 list of components. Most utilities will use the existing equipment/component tracking systems with an additional field for RISC-3. The list is necessary to separate the components in the former safety-related list into the two separate categories, such that treatments for RISC-3 components can be appropriately adjusted.

For harsh environment electrical equipment (former 10CFR50.49 equipment), the existing EQ is the RISC-3 accident function assessment until an assessment of the EQ constraints is performed. If the utility chooses not to do this assessment, the EQ required actions remain in place and no additional documentation is required. If an assessment of the constraints is performed, the assessment results should be documented to allow future access to the assessment. The assessment does not need to be performed under nuclear quality assurance requirements. The results could be documented in the form of a calculation or some other retrievable document or could be maintained in the procurement files for the component.

When used as all or part of the RISC-3 accident function assessment, the former EQ file is a reference and does not become part of the RISC-3 AFA. If an EQ file (binder) is used as the basis for an accident function assessment or reduction of constraints analysis, it can be a historical file and does not need to be maintained as an active EQ file if it no longer applies to EQ devices that remain in service. To comply with 10CFR50.69, the design basis functional requirements for RISC-3 components must be maintained.

The configuration requirements necessary for RISC-3 components to maintain accident function will need to be documented to allow procedures for installation and maintenance to be prepared. In addition, if maintenance, surveillance, or calibration requirements are deemed necessary to establish reasonable confidence in accident function, these too will need to be documented and retrievable. The documentation and filing systems do not need to conform to 10CFR50 Appendix B.

## 5.6 Preparation of an Accident Function Assessment

The development of an AFA starts with determining the design basis environments and service conditions applicable to the RISC-3 component under consideration. Although the use of the enveloping EQ accident environments is not recommended as the environmental requirement for AFA, grouping RISC-3 components with respect to the same or similar design basis environment and service requirement is recommended. Grouping will reduce the number of AFAs that must be generated. Table 5-1 provides a listing of the major sections of the AFA.

**Table 5-1**
**Suggested Subsections of an Accident Function Assessment**

| Subsection | Basic Content |
|---|---|
| 1. Accident Conditions | Peak temperature, peak pressure with applicable profile and duration.<br><br>Radiation dose (may include normal dose).<br><br>Steam condition (if applicable). |
| 2. Normal Conditions | Normal temperature, process information (if applicable), operating mode (normally energized or de-energized). |
| 3. Device Description | A basic description of the component being assessed. |
| 4. Attributes | A listing of the key attributes of the device (for example, materials, connections, mounting, seals, and valve seat materials). (Appendix G indicates attributes that may be important to environmental withstand capability.) |
| 5. Assessment of Environmental Capability | Environmental seal.<br><br>Thermal capability of subcomponent capabilities (for example, coil, leads, valve seats, and seal materials).<br><br>Overall radiation capability of components.<br><br>Mechanical cycling (as needed). |
| 6. Summary of AFA Conclusions | |
| 7. Maintenance, Surveillance, and Calibration Requirements | |
| 8. Installation Requirements | |
| 9. Directions for Procurement Organization | |
| 10. References | |

The following indicates the basic content of each section of an AFA.

**1. Accident Conditions**
The first section establishes the accident conditions to be considered. The temperature, pressure, steam, and radiation conditions for the components are stated. The radiation dose can be the total integrated dose (that is, includes both the normal and accident doses for the installed duration [the point of installation until the end of plant life]).

**2. Normal Conditions**

The normal temperature is stated. Although design temperatures can be used, the actual temperature that is normally experienced is more desirable for RISC-3 components and will generally be significantly lower than the design temperature.

For devices mounted on process lines or having process fluids flowing through them, the process temperature should be stated. If the process fluid flows through the device, the process medium should be stated. For motors, the application and load should be stated.

**3. Device Description**

The device type, model number, and a simple description of its basic design are provided.

**4. Attributes**

The key attributes are different for each type of electrical component. Component attributes are those component material or design characteristics that are considered important to functionality during the accident conditions. The attributes should be those of the actual component being used. As shown in the examples in Appendix H, “Examples of Accident Function Assessment Development for Non-Equivalent Replacement Items,” many of the attributes are critical to the design of the application but are not critical to accident function assessment. In the examples, the items important to accident function assessment are shown in bold type.

**5. Assessment of Environmental Capability**

In this section of the AFA, the environmental seal (if needed) and the determination of its adequacy in preventing moisture ingress are described. The thermal and radiation capability of the materials and components of the device are evaluated with respect to accident and normal service conditions. The assessment also includes consideration of the operating cycle limits for the device.

**6. Summary of AFA Conclusions**

This section states the conclusions of the AFA and any limitations or key assumptions related to the conclusion.

**7. Maintenance, Surveillance, and Calibration Requirements**

This section lists any maintenance, surveillance, or calibration requirements that result from the development of the AFA. Sealing requirements and replacement requirements due to thermal, radiation, or cyclic limitations are stated. If the requirements are derived elsewhere in the AFA, they can be simply stated here. Manufacturers’ requirements that form part of the basis of the AFA should be stated here. For example, a manufacturer may have a cyclic limit based on the assumption that the device is mounted in a vertical or near-vertical position, and so this section should require that the device be installed vertically. (If the device cannot be repositioned after being initially installed, this requirement could be placed in the “Installation Requirements” section.)

**8. Installation Requirements**
Any requirements concerning required configuration controls needed to support accident function, such as electrical housing seals, component orientation, and drainage, should be described here.

**9. Directions for Procurement Organization**
This section lists any procurement options that are necessary to support the AFA conclusions. For example, both the materials that are acceptable for valve seats and body seals as well as the coil rating should be stated. Any materials (such as Teflon) that must be excluded should be stated. The necessary housing design should be stated if different options exist.

**10. References**
The references used in the development of the AFA should be listed.

### *5.6.1 Potential Sources of Accident Function Assessment Development Information*

Table 5-2 shows the items included in the AFA, the associated concerns, and possible sources of information. Examples of AFAs are provided in Appendix H. Considerations for subcomponent susceptibility are provided in Appendix G. Appendix A provides information on the capability of materials commonly used in components that are used in nuclear plant applications. Appendix D provides thermal aging assessment equations.

**Table 5-2**
**Accident Function Assessment Items, Concerns, and Information Sources**

| AFA Item | Concerns | Possible Sources of Information |
|---|---|---|
| Accident conditions | Design basis requirement must be identified. | UFSAR accident analysis chapter and area normal and accident dose calculations. |
| Normal conditions | Actual temperatures must be obtained, if available; design calculations if not. | Previous temperature survey information, operator logs, design calculations. |
| Device description | The nature of the device and the basic function it performs must be described. | Application and safety function description. |
| Attributes | The attributes of the device that are important to accident function assessment are to be defined. | Appendix G of this report; manufacturer's description of the device; basic knowledge of component, its function, and susceptibilities to environment. |

**Table 5-2 (cont.)**
**Accident Function Assessment Items, Concerns, and Information Sources**

| AFA Item | Concerns | Possible Sources of Information |
|---|---|---|
| Assessment of environmental capability | If a steam or condensing moisture condition occurs, the need for sealing must be established. Electronic devices must be sealed if moisture or steam could be present. Some electromechanical devices (for example, limit switches) generally need to be sealed; some (such as motor operators and certain solenoid-operated valves) do not need an absolute seal but do need drains and housing configurations that prevent direct impingement of water and steam on internals. | If seals are needed, pressure-retaining capability of housing and seal system can be evaluated.<br><br>If seal is not needed, direct impingement and drainage can be assessed; drip loops on leads can be used if terminal blocks are used.<br><br>Note: Many successful industry tests of motor control center and load center components exist in which the cavities were not fully sealed. Physical setup to prevent puddles of water at terminations is the key to success in high-energy line breaks (HELBs) for these components. |
| | An evaluation of the thermal and radiation effects of the accident on the device is to be performed. | The manufacturer's literature will provide basic capability of the component. For conditions beyond published capabilities, Appendix A provides materials capabilities data with respect to temperature and radiation as do numerous industry databases. For severe thermal conditions such as inside-containment LOCA and main steam line break (MSLB), operability tests at elevated temperature may be necessary. |
| Aging and synergistic considerations | Effect of thermal aging must be determined. | A judgment on whether aging will adversely affect accident function is made. If aging could be specific, a life based on operating experience or thermal analysis of materials capabilities (see Equation D-1 and Appendix A) may be made. If the expected normal radiation dose exceeds 5 Mrd, the effects of known synergisms should be addressed. |
| | Effects of mechanical cycling must be determined. | Manufacturer's literature generally provides a basis for limits of cycling of switches, relays, and solenoid valves that far exceeds the needs of most applications. |
| Summary of accident function assessment | Conclusion of acceptability must be determined. | This section summarizes the conditions under which the device can be used and concludes that the device is acceptable for performance of design basis function with respect to environments throughout its service life. |
| Directions for procurement | Any limits or options that must be placed in the procurement documents must be identified. | Based on the AFA, any exclusions of materials or options that are necessary for performance of design basis function with respect to environment are stated. |

## 5.7 Accident Function Assessment Concepts

If the device has been environmentally qualified per 10CFR50.49, or if a related device has been environmentally qualified, the associated EQ report can be used as the basis for the accident function assessment. If the environmentally qualified device is being purchased, the report can be used directly, and the techniques described in Section 6, "Relaxation of EQ Constraints for Applications Categorized as RISC-3," can be used to relax constraints of the EQ to be consistent with a reasonable confidence basis.

Establishing a RISC-3 AFA basis for a component is significantly different from the highly prescriptive methods used to establish EQ under 10CFR50.49. Reasonable confidence in the performance of accident function can be achieved in many ways, depending on the nature of the device and its normal and accident environment. These include:

- Exclusion of materials susceptible to the specified conditions (for example, exclusion of Teflon from components in elevated radiation environments [>10,000 rads])
- Acceptance of the specified conditions by the manufacturer/vendor
- Evaluation of the component
- Limited testing for a specific condition(s) with other conditions covered by catalog information, reference literature and data, or analyses

Under 10CRF50.69, a broad range of data and information can be used in the development of an accident function assessment for a RISC-3 component. The following examples of vendor and industry information can be used:

- Industrial information: Some industrial components are manufactured in accordance with industry codes (for example, ASME, IEEE, and MIL SPEC) that envelop severe environmental conditions.
- Brochures: Equipment brochures are typically focused on marketing and therefore may provide only an overview of the equipment capabilities and some minimal engineering information. However, in some cases, the brochure identifies sufficient environmental functionality that would envelop the requirements of a RISC-3 application.
- Catalog sheets: Catalog sheets are more detailed than brochures and contain more data related to a component. In general, the data apply more to engineering and construction purposes and may or may not contain information related to accident function.
- Letters: A letter from the vendor is useful when a catalog sheet or brochure is insufficient to document the RISC-3 AFA functionality of the equipment.
- Telephone conferences: A telephone conference is typically useful if the appropriate vendor technical contact is known because it allows the RISC-3 AFA assessor to ask direct questions concerning the applicable equipment.

- Test reports: Test reports are typically proprietary documents, although vendors will often summarize results in other documents or correspondence. It is considered acceptable for RISC-3 AFA purposes to reference a test report without having the test report as part of the plant documentation control, although it can be beneficial to have the report. Note: These test reports do not need to be nuclear EQ reports nor do they need to have been produced under nuclear quality assurance controls. The tests may be for independent effects and do not have to conform to any specific sequence of testing, nor do they need to be performed on the same test specimen.

Because the IEEE Std 323 [10] concept of **sequence** does not apply, the various types of aging stresses and accident period stresses can be considered separately. Technical personnel preparing RISC-3 AFA bases can consider stresses independently, but they should consider whether the exposure to one stress (for example, thermal stress) does not completely consume a material's capabilities such that there is no capability to withstand the other stresses (for example, irradiation). When the combination of stresses is very high with respect to device or material capabilities, testing may be necessary to confirm the acceptability of a device for use.

## 5.8 Assessment Strategies

Several factors determine whether a component will function through accident environments and service conditions. These include:

- The severity of the accident environment (temperature, radiation, steam, and sprays)
- The severity of accident service conditions (voltage, operating cycles, and duration of need)
- The hardiness of a component with respect to accident environments
- The degree of normal service-condition-related degradation of the component that reduces its hardiness with respect to accident environments and service conditions

For populations of equipment used throughout the spectrum of harsh environments in a plant, there are variations from relatively benign accident conditions to rather severe accident conditions and similar variations in normal environments. Separating accident conditions into logical groupings with respect to relative difficulty of equipment to perform a function is a useful concept. Components have varying capabilities to withstand harsh environment conditions and the rigors of normal service. Many components are capable of withstanding relatively benign accident conditions; few are capable of withstanding the harshest accident conditions. Developing an understanding of the basic environmental capability of the types of components that are likely to be classified as having RISC-3 applications is useful especially when trying to determine the degree of difficulty that can be expected in preparing an accident function assessment.

### 5.8.1 Transition from Worst-Case Focus

When the bases for EQ were established, the tendency was to qualify a component type for the most stringent set of performance requirements and the worst-case environment in the plant, thereby allowing its use anywhere in the plant. This strategy can be used for RISC-3 components as well, but it may constrain the sources of procurement—especially in cases where the component is used inside and outside containment or in HELB areas and radiation-/temperature-only areas. Under the worst-case approach, procurements may need to be limited to essentially buying the environmentally qualified version of a component such that costs may not be significantly lowered. If only a few applications are located inside containment, the procurement could be separated into two or more environmental groups such that the need for the equivalent of the fully qualified version is limited to a few devices, and a less capable device could be used for replacement of the remainder of the population. Table 5-3 provides the basic break points between the environments.

**Table 5-3**
**Environmental Groupings Versus Component Capability**

| Environment | Component Capabilities |
|---|---|
| Elevated temperature and/or radiation only | Many devices acceptable |
| Low-pressure transient steam event (for example, most HELBs outside containment) | Many devices acceptable with limited sealing or appropriate installation practices |
| LOCA/MSLB inside containment plus significant accident radiation | Devices able to withstand wetting, high-pressure steam, chemical spray, high temperature, and radiation needed |

The STP[9] experience provides insights with regard to various electrical harsh environment device types that will be categorized as RISC-3. Table 5-4 provides a list of RISC-3 inside-containment electrical components with accident functions and the approximate distribution[10] based on initial STP efforts. Similarly, Table 5-5 lists RISC-3 components located outside containment and their distribution. Connectors, terminal blocks, splices, shrink tube insulation, and cables are also associated with RISC-3 applications and would be treated under the rules for RISC-3 applications. Although the quantities of specific devices apply only to STP, the types of components listed in Tables 5-4 and 5-5 are expected to be representative of those of other PWRs. These tables apply to the components that formerly required EQ per 10CFR50.49 and do not represent all of the RISC-3 population. It is possible that an electrical containment penetration may service only RISC-3 applications. However, the electrical penetration typically remains a containment pressure boundary and might not be categorized as RISC-3.

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[9] The South Texas Project (STP) has been licensed to use a risk-informed safety categorization approach independent of the issuance of 10CRF50.69. STP has implemented a reduction of the special treatment requirements.

[10] The STP distributions are provided for information only and are not expected to be representative of other plants that implement the 10CFR50.69 process.

**Table 5-4**
**Possible RISC-3 Inside-Containment Devices: Number of Devices**

| Inside-Containment Devices | Number of Devices |
|---|---|
| Blower motors | 10 |
| High-range radiation monitor | 2 |
| Limit switches | 96 |
| MOVs | 31 |
| RTDs | 34 |
| SOVs | 2 |
| Transmitters | 32 |
| Total number of inside-containment components | 207 |

**Table 5-5**
**Possible RISC-3 Outside-Containment Devices: Number of Devices**

| Outside-Containment Devices | Number of Devices |
|---|---|
| Blower motors | 15 |
| Flow switches | 2 |
| Heaters | 2 |
| Level switches | 3 |
| Limit switches | 178 |
| MOVs | 32 |
| Pressure switches | 4 |
| Relays (electromechanical) | 10 |
| SOVs | 90 |
| Temperature switches | 20 |
| Transmitters | 30 |
| Total number of outside-containment components | 386 |

Inside containment, there are essentially five types of devices with a sizable population: limit switches, motors, motor operators, transmitters, and resistance temperature detectors (RTDs). The outside-containment sizable populations are typically limit switches, motors, motor operators, solenoid-operated valves (SOVs), temperature switches, and transmitters. The components located outside containment are relatively hardy devices with respect to expected accident environments. Given the expected component types for RISC-3 outside-containment applications, the difficulty in preparing accident function assessments should not be significant.

With respect to the inside-containment component types, the effects of moisture ingress from the high-pressure steam condition of the LOCA/MSLB can be significant, and care in establishing component seals or drains (as appropriate) is important. Transmitter electronics will be sensitive to high levels of gamma radiation (transmitter casings will significantly reduce beta doses to internal components). The use of actual plant design radiation doses for gamma and beta rather than a bounding 200-Mrd requirement is recommended. For transmitters with capacitive detectors using fill fluids, certain fluids will be sensitive to elevated radiation and temperature, and care must be taken to ensure that the proper fill liquid in RISC-3 applications is used. Developing RISC-3 accident function assessments for inside-containment applications will be more difficult than developing bases for outside-containment applications. Relating the RISC-3 accident function assessments for inside-containment RISC-3 applications to an existing EQ is likely until experience is gained with the development of accident function assessments for inside-containment equipment.

## 5.9 Material and Component Capabilities

The materials of construction of a component greatly affect the likelihood that it will withstand a given set of environmental stresses, especially severe ones. Some materials withstand temperature and radiation well; some materials have superior thermal capabilities but are not acceptable for high dose radiation environments; other materials, called *thermoplastics*, can withstand temperatures up to 60°C or higher for long periods but soften and lose structural integrity at temperatures approaching their melt point; and some materials are satisfactory for many conditions but are sensitive to oil and chemical environments. The use of the appropriate material for the conditions of service is important.

The following subsections describe the effects of the severity of environmental conditions with respect to the inherent capabilities of the materials in a component. These subsections describe the differences in environments and their effects on basis component types: electromechanical, electronic, passive electrical, and termination systems. The subsections also include considerations for material susceptibilities for various stresses and stress levels.

### *5.9.1 Thermal- and/or Radiation-Only Accident Environments*

The definition of **mild environment** for a plant will determine the threshold for beginning consideration of accident function assessment. Most plants have the threshold for harsh environments starting above 40°C for temperature and 10,000 rads for radiation for components other than electronics, which generally have a threshold of 1000 rads. Elevated temperature and radiation under dry (that is, noncondensing moisture) conditions is generally associated with secondary effects of inside-containment accidents. Elevated temperatures and radiation levels can occur in rooms outside containment via circulation of process fluids, equipment heat loads, or from heat transfer and radiation shine through containment walls. Thermal-/radiation-only accident conditions can range from quite minimal to fairly significant.

#### 5.9.1.1 Temperature Effects

The two temperature concerns for electrical components are direct thermal effects and long-term exposure effects. Direct effects of elevated temperature can soften thermoplastic materials, which causes them to deform. High temperature can also cause thermal trip devices in molded-case circuit breakers (MCCBs) and overload relays to operate at lower operating currents. Long-term exposure to elevated temperature enhances the degradation of organic materials.

For organic materials, elevated temperature causes thermal aging to proceed somewhat more rapidly than for a lower temperature. The effects of a moderately elevated temperature (for example, 75°C) for a few days will cause some deterioration, but it will not severely deteriorate most of the materials used in electrical components. Most outside-containment accident conditions do not have long-duration, high-temperature conditions. High temperatures (that is, >100°C) from HELBs do not last for more than a few hours and often last for less than an hour and then return to normal temperatures over the course of a few hours to days. Secondary effects from a LOCA or MSLB may cause longer but much lower temperature conditions with peaks between 60 and 70°C. In general, the amount of thermal degradation from outside-containment accident conditions will not significantly challenge the organic materials of electrical components unless the temperatures are high for long periods of time. Even then, depending on the materials of construction, the deterioration may not be excessive with respect to overall capability.

Figure 5-1 provides equivalency multipliers to estimate the aging effect of elevated accident temperature on components to compare the period at elevated temperature to 50°C. The figure is based on the Arrhenius aging model (see Appendix D) for activation energies between 0.9 and 1.2 eV, which are typical for many materials used in industrial components. At 65°C, the aging is between 4.5 and 7.5 times as fast as at 40°C. Accordingly, for each day at 65°C, the device would age the equivalent of 4.5 to 7.5 days at 40°C. Even if the device remained at 65°C for one month, the aging would essentially be equivalent to only 4.5 to 7.5 times normal aging. Essentially, such an accident environment would reduce the life of the device by approximately 1/2 year. In comparison to the life capability of most devices, this should not be significant. However, if the device were exposed to 80°C for one month, the multipliers would be between 18 and 48 times, with the equivalent time being between 1.5 and 4 years at 40°C—which may be appreciable with respect to normal life. If the thermal equivalency of the accident period is relatively high (for example, is expected to consume the equivalent of a number of years of service capability), a review of the overall capability of the materials of the device may be desirable.

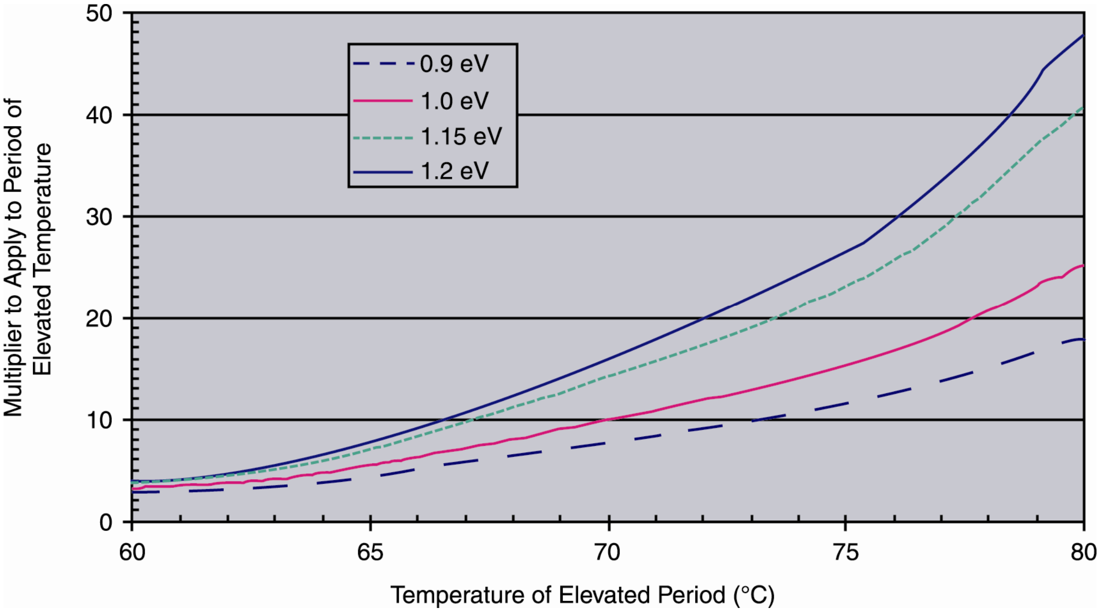


**Figure 5-1**
**Multiplier to Equate Periods of Elevated Temperatures to 50°C**

*Components with Thermal Concerns*

### Components Containing Thermoplastic Materials

Two basic types of plastics that are based on intermolecular bonding are **thermoplastics** that have little intermolecular cross-bonding and **thermosets** that have strong intermolecular bonding [11]. Thermosets harden when manufactured and take a permanent shape, and they do not soften at elevated temperatures of practical interest.

Thermoplastic materials soften at elevated temperatures and can deform. Thermoplastic materials are used in some electrical components as structural components, safety shields, and termination components. Thermoplastic materials must not be exposed to elevated temperatures under accident environments that could lead to softening if the material is important to the function of a device. Appendix A provides more details on thermoplastic materials. Manufacturers can identify devices having thermoplastic materials. If information is not available on softening of the materials of construction for a component with thermoplastic materials, a simple oven exposure for a few hours at the operating temperature followed by a functional test at elevated temperature will indicate if a problem exists. The softening, if it is a problem, happens readily, and deformation of covers and structural components can be identified easily. The materials do not fully return to their original state when cooled.

Thermoplastic devices do not necessarily age more rapidly than thermoset materials and are frequently good materials for construction of components as long as their operating temperature is maintained well below the softening temperature.

### Electronic Components

An elevated temperature can cause instantaneous failure of electronic components, especially power electronics such as diodes and silicon-controlled rectifiers (SCRs). An elevated temperature can also cause output shifts or changes in characteristics of electronic circuits. If the junction temperature limit of an electronic device is exceeded, the junction can fail readily. When elevated accident temperatures are possible, the manufacturer of an electronic component should be contacted to determine the known temperature limit for the component. If the temperature limit is not known but is expected to be higher than the temperature limit listed in the manufacturer's literature, a thermal operability test may be performed in which the operating device is subjected to the elevated temperature in an oven for a reasonable duration.

### Molded-Case Circuit Breakers and Overload Relays

The casings of most MCCBs are made from phenolic or glass-filled polyester, which are temperature-stable, thermoset materials. Accordingly, there is no concern for deformation of MCCB casings and the structural function they perform under outside-containment accident temperatures. Overload relay casings can be phenolic, glass-filled polyester or, in some cases, thermoplastic materials. Accordingly, if the casing material is not known and the overload relay may be exposed to >100°C, the materials of construction should be determined. Devices with thermoplastic casings should not be used in applications where conditions may approach their softening temperature. (Note: Exposing an overload relay to >60°C will significantly affect its set point.)

Some MCCBs have thermal overload trip devices. Most overload relays are based on ohmic heating from operating current. Changes in ambient temperature beyond 50°C affect the set points of these devices such that nuisance trips can occur at normal load current levels. The manufacturer of the MCCB or overload relay should be consulted to determine the temperature at which derating may be necessary under accident environments to ensure proper operation of the connected load.

The materials used in MCCBs and overload relays have long thermal lives such that normal aging and short- to moderate-term exposure to elevated temperatures have little effect on structural strength and no effect on dielectric properties.

### Electromechanical Components

Most electromechanical components are capable of operating at temperatures exceeding their published temperature limits for short durations but may experience degraded capability and some accelerated thermal degradation during moderate- to long-duration elevated temperature events. For example, the locked rotor torque of motors may decrease and the minimum pull-in voltage of solenoids and relays may increase when operated at temperatures in excess of published temperature limits. Short-duration, limited-peak temperature (<100°C) conditions

should not cause significant problems with component functionality and degradation.[11] No problem would occur for a component that completes its function at or very near the start of the period of elevated temperature. However, accidents with relatively long, elevated temperature (>121°C) periods that cause components to experience significant increases in operating temperature could cause a problem if a component must operate after its temperature has become elevated.

### 5.9.1.2 Radiation Effects

With respect to non-electronic, electrical, and electromechanical devices, radiation doses below 10,000 rads have no effect on operability of components. Figures A-1 through A-5 in Appendix A of the EPRI report *Radiation Data for Design and Qualification of Nuclear Plant Equipment* (NP-4172SP) indicate that 10,000 or more rads are needed to produce observable (threshold) changes in the properties of most materials [12]. Above that level, the first material to show an observable change is Teflon at 20,000 rads.

The 25% change dose for Teflon is 34,000 rads. Butyl rubber has a 25% change dose that ranges from 700,000 rads to well above 1 Mrd. All other materials have 25% change doses of at least 1 Mrd. Unless a capability of greater than 10,000 rads is needed, no common organic material needs to be excluded. Above 10,000 rads, Teflon should be excluded from use. If a 1-Mrd capability is required (which is rare for radiation-only environments), then Teflon and butyl rubber should be excluded. Alternately, results from a radiation exposure test could be used to prove functionality. For radiation doses above 1 Mrd, Figures A-1 through A-5 in EPRI report NP-4172SP provide threshold dose and 25% change property change levels. Most materials should be functionally acceptable for applications with doses in excess of the 25% change property, but functionality concerns are likely to exist for doses in excess of a 50% property change.[12] Use of the 25% change value is conservative and addresses capability differences among differently formulated materials within a material class (for example, EPR rubber). Alternately, results from a radiation exposure test could be used to prove functionality. The EPRI report NP-4172SP (which is the source for Figures A-1 through A-5) provides further information, as do nuclear industry materials databases commonly used to support EQ [12].

**Electronics Exposed to Radiation**

With respect to electronics, some devices are more radiation sensitive than others. Radiation-hardened electronics exist, but are not generally used in industrial equipment. Military specification (MIL SPEC) electronics may be available with higher radiation withstand

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[11] The thermal energy content of an accident profile is proportional to the peak temperature and its width. If the peak is extremely high, the thermal energy content will be relatively high even if the duration is short. Component housings and casings will dampen the peak temperature experienced by internal components, but at the same time they broaden the elevated temperature experienced by the internal components. Internal components will not experience the peak temperature, but they will experience a lower peak temperature of longer duration.

[12] Similarly, UL 746B, *Polymeric Materials - Long Term Property Evaluations*, suggests that thermal ratings for materials can be based on a 50% loss of physical or electrical characteristics.

capabilities. The commonly used radiation threshold for concern for electronics that contain metal oxide semiconductors (MOSs) is 1000 rads [12]. Below 1000 rads, there is no significant concern for functionality of industrial electronics. Most electronic components can withstand at least $10^3$ rads. Section 3 of EPRI report NP-4172SP describes radiation effects on semiconductors and provides references to further material [12].

If the electronics are located inside an unvented metal housing, the gamma radiation would be the key concern and the beta would not be important because the housing would stop the bulk of the beta from affecting the electronics. Devices with sealed housings include electronic transmitters and flow switches. However, most power supplies have vented housings. The subcomponents of concern with respect to radiation exposure are semiconductors. Different types of semiconductors have different abilities to withstand irradiation without failing. The manufacturer of an electronic device may have radiation information on semiconductors if the device is already used in the nuclear industry or in military applications.

### 5.9.2 Low-Pressure, Transient Steam Events

Low-pressure, transient steam events, such as HELBs, are the result of a steam pipe break outside containment. The pressure for such events is below a few psig, and the duration of the elevated pressure is short because building panels blow out and relieve the pressure. The duration of the overall event is short because the break is typically isolated in a short period. The peak temperature of the events can range from just above boiling to approximately 232°C, but the pressures are very low and generally of short durations. Because the pressures of the outside-containment HELBs are so low, the associated saturation temperature barely exceeds 100°C, and component internal temperatures associated with them should not approach 100°C. Section A.5.4 of the EPRI report *Nuclear Power Plant Equipment Qualification Reference Manual* (TR-100516) describes exposure to superheated low-pressure conditions and the resulting thermal lag on the interior of components [13].

Because pressures are low, relatively little moisture is actually forced into most components unless they are fully vented (for example, have sections of open grill work) and steam essentially flows through the structure. With the exception of electronic devices, the key functionality concern is to prevent significant amounts of condensing moisture from the outer surface of the component from entering the device and bridging electrically separated conducting elements (for example, causing puddles around exposed connections). Steam condensing on the surface of electronic boards can immediately affect circuit operation.

Although keeping electrical equipment dry is a good practice, motor control centers, load centers, motors, and control panels are often exposed to highly moist conditions in industrial and fossil plant applications without causing failure. Although most manufacturers' catalog descriptions limit use to 95% humidity, existing HELB tests for electrical components have shown that electrical separation within such devices is often adequate under condensing moisture

conditions unless direct dripping or wetting occurs at terminations. Reasonable care in the installation and design of most electrical components can preclude shorting or bridging of connections in the following ways:

- By having side or bottom entry conduits
- If top entry conduits are used, by sealing around the conduits and not placing terminal blocks directly under the conduit entry point
- By sealing the top of panels or cabinet to preclude moisture accumulation from draining into the panel.
- By placing drip loops in wires leading to terminal blocks
- By not placing connections on the bottom of cabinets where water could accumulate and cause shorting

In addition, energized components generate heat such that cabinets and housings and components within them are hotter than the surrounding environment. This warming raises the component temperatures above the dew point, which further reduces the likelihood of condensation and helps to dry the component as conditions normalize following the event.

### 5.9.2.1 Electronics

Electronic circuits can easily be bridged if moisture condenses on circuit boards. The moisture may not cause permanent failure but may cause the circuit to shut down, the calibration to shift, or some other malfunction to occur. When the circuit has dried, the device may function as normal, or it may have been permanently damaged. Depending on the nature of the device, full sealing may be required or conformal coating may be applied to the circuit board.

For unsealed electronics that must operate through a low-pressure, transient steam condition, the ability of the device to withstand moist conditions with elevated temperature should be confirmed with the manufacturer/vendor. If the device is sealed against moisture, the only concern is elevated temperature and radiation (if applicable). Low-mass electronic components that are not housed inside larger, more massive structures may heat rapidly such that significant internal heating may occur (for example, although the internal temperature of the device will not increase to the peak steam temperature, internals may reach 170 to 200+°F (77 to 93+°C), depending on component temperature rise, heat transfer rate, as well as steam peak and duration). Accordingly, electronic devices subjected to HELBs should be suitable for the postulated high-temperature conditions, or they should be subjected to elevated temperature operability tests in addition to confirmation of operability at the elevated temperature.

For electronic devices that can experience radiation as well, the concerns in the previous subsection (5.9.1.2) apply.

Appendix B describes the results of a test of a pressure transmitter that did not have conduit seals on the termination cavity for the 4–20 mA connections. The transmitter remained accurate when exposed to a HELB with a peak temperature of 286°F (141°C) and a short-term pressure of

41 psig. The test was purposely devised with the conduit draining toward the transmitter from an unsealed junction box (that is, multiple fully open conduit openings to the chamber environment). The test proves that full sealing of the termination cavity is unnecessary for HELB conditions for an electronic transmitter. The transmitter used in the test presented in Appendix B has two separate compartments with a seal between them. The electronics sit in one compartment and the terminations in the other, and there is a seal with termination feedthroughs between the two compartments. The feedthroughs are more than capable of withstanding the pressure of a HELB and the 40-psig peak pressure that occurred during the test.

### 5.9.3 Full Loss-of-Coolant Accident and Main Steam Line Break Conditions

The verification of accident function to the enveloping conditions of the inside-containment EQ profile is difficult. The verification of accident function for the actual accident profiles is somewhat easier in that peak temperatures are lower and their durations shorter. If an EQ report exists for the same or a similar device, accident function assessment is much easier. Under RISC-3 accident function assessment, portions of EQ reports can be used to support qualification for different devices or different manufacturer’s components. For example, some devices have housings similar to Rosemount 1153 transmitters. Accordingly, if electrical components are contained in a housing like the Rosemount 1153 transmitter and have similar thread sealants, electrical port seals, and cover gaskets, credit could be taken for having an adequate environmental seal for the device. The accident function assessment would then focus on the ability of the internal components to function under elevated temperature and radiation conditions.

The first question in developing an accident function assessment is: “Does an EQ report(s) related to the device or portions of the device exist?” Potentially useful reports include those that cover:

- A related device from the same manufacturer
- A related device from a different manufacturer
- A similar housing seal system and/or electrical feedthrough
- Similar electronics or mechanism of an electromechanical device
- A related device with similar subcomponents (for example, to establish radiation and temperature capability of electronics or a particular component within a different but acceptable housing)

When preparing an accident function assessment for an inside-containment component through the use of an existing EQ test report for a component that is similar but not identical to the RISC-3 device, one must review the differences between the RISC-3 device and the device that was qualified. Not all differences matter. Although in some ways similar to an equivalency evaluation, the evaluation determines the attributes that are covered by the existing EQ report

and the attributes that need further assessment. Table 5-6 provides a listing of some key concerns for RISC-3 accident function for inside-containment accidents. Examples of identifiable differences and their resolutions for typical devices that could be categorized as RISC-3 are presented in Appendix G.

**Table 5-6**
**Component Concerns Related to Inside-Containment Accident Function**

| Similarity | Concern | Resolution |
|---|---|---|
| Housing: sealed system | RISC-3 seal is comparable | The RISC-3 component's housing must be able to withstand pressure. Seals must be capable of withstanding pressure at peak temperature. (Note: An irradiated seal is not likely to need to withstand full accident pressure because peak pressure occurs very early in the accident. The total integrated dose [TID] is low at the beginning of an actual accident.) |
| Housing: unsealed system | Water accumulation within the device | The RISC-3 component must be drained in a similar fashion to preclude water accumulation that could affect electrical parts. Terminations should be similarly arranged to preclude bridging. |
| Housing gaskets | Similar arrangement and similar materials | Gaskets and O-rings used in seals should have similar physical arrangements. The materials should either be the same or have better thermal and radiation degradation capability. |
| Mechanism | Similar type and similar materials | The mechanical arrangement of an electromechanical device should be similar. The organic materials used should either be the same or have better thermal and radiation degradation capability. If the housing is unsealed, the metals used should have equal or better corrosion resistance. |
| Electronic components | Equal or better peak temperature and radiation dose withstand | Electronic components should be directly related by component types and circuit arrangement. |
| Electrical coils | Coil insulation and mounting system can withstand the temperature, moisture, and radiation conditions | The coil wire insulation and encapsulation system should be similar. |

The degree of effort in preparing a RISC-3 accident function assessment for a LOCA/MSLB is somewhat eased when the design basis profiles rather than an enveloping profile are considered. Figures 5-2 and 5-3 show a possible PWR LOCA/MSLB for 8 and 9000 hours. The peak temperature is 262°F (128°C) with the peak having a duration of approximately 1/2 hour. At 8 hours, the temperature is 200°F (93°C) and at 800 hours (33 days), the temperature is 135°F (57°C). Although this is not a benign profile, it is much less severe than a traditional enveloping LOCA/MSLB test profile that has a peak in excess of 340°F (171°C) that lasts for 3 hours, followed by 3 more hours at 320°F (160°C), followed by long periods at 250–300°F (121–149°C).

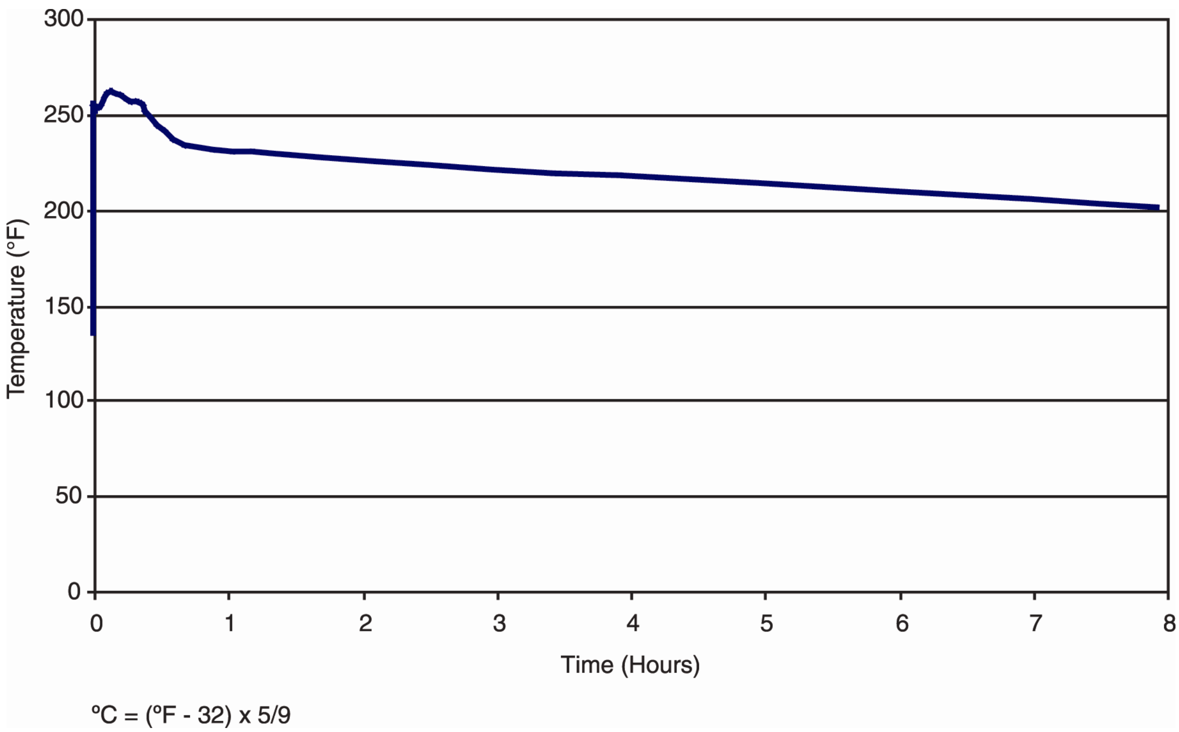


**Figure 5-2**
**Typical PWR Loss-of-Coolant Accident and Main Steam Line Break Thermal Profile (First 8 Hours)**

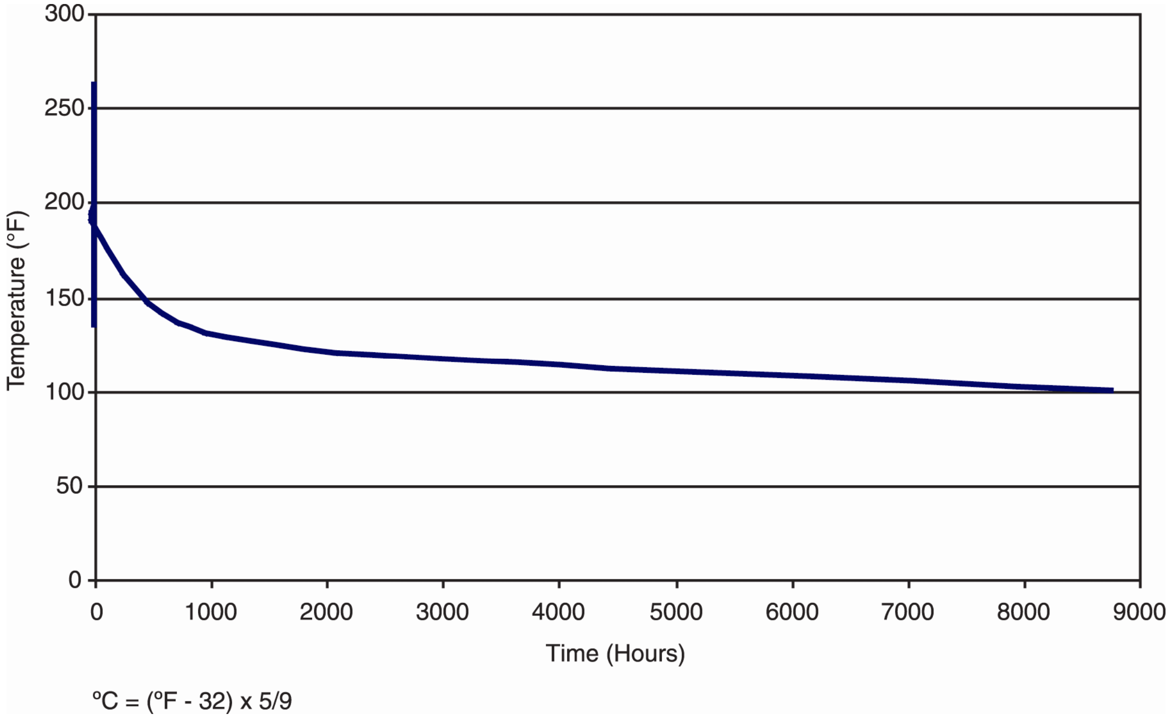


**Figure 5-3**
**Typical PWR Loss-of-Coolant Accident and Main Steam Line Break Thermal Profile (9000 Hours)**

After the need for sealing has been resolved (that is, the device must be sealed or it can be semi-sealed or unsealed), temperature and radiation capabilities must be considered. If a device can be shown to be functional at the peak temperature (for example, it does not suffer an instantaneous failure from the elevated temperature), the key concern is that the organic materials do not degrade excessively from the thermal and radiation stress. If a device has been sealed, an operability test in an oven at the peak temperature for a reasonable duration could be used to resolve concerns related to operation at the peak temperature. Thermal aging and radiation data from tests of related materials could be used to determine whether continued operation during the remainder of the thermal profile and accumulating radiation dose would be a concern.

Many of the components in the list of inside-containment RISC-3 devices at South Texas Project (see Table 5-4) are relatively rugged devices (such as limit switches, RTDs, motors, and motor operators) having materials that are designed for high-temperature operation and that are generally satisfactory for radiation. Accordingly, accident function assessments for inside-containment components could be developed without having an existing EQ. However, the effort required may be significant, and one must be careful. Accident function assessments for inside-containment components will be much easier to develop when one or more related qualification documents are available to use as the basis for key issues such as sealing as well as thermal and radiation withstand of subcomponents.

The development of an accident function assessment for a motor has some of the special concerns for inside-containment components. Motors are rarely completely sealed against inside-containment motor accident conditions. Even totally enclosed and explosion-proof motors can permit water/steam entry around the shaft seal and through the termination box, vents, and drains. Water and chemicals can attack winding insulation and cause deposits between the rotor and stator. Accordingly, care must be taken to ensure that such motors can withstand the ingress of moisture and chemicals that are associated with steam and spray conditions inside containment. Developing a basis for winding capability under moisture and chemical conditions without test information will require considerable care and effort.

With regard to replacement seals and gasket materials, materials evaluation of original components (for example, Fourier Transform Infrared Spectroscopy) can be used to establish the type of material to be specified for further use in RISC-3 applications whether the application is inside or outside containment. Once the material is known, commercial replacement materials could be substituted for the qualified version. Likewise, the manufacturer could supply replacement components having the same material descriptions but without nuclear-grade documentation.

# 6
# RELAXATION OF EQ CONSTRAINTS FOR APPLICATIONS CATEGORIZED AS RISC-3

## 6.1 Introduction

When safety-related EQ applications are categorized as RISC-3, they will have an existing qualification with EQ-required calibration, maintenance, and replacement schedules. A new alternate treatment does not need to be prepared because the existing EQ device and its documentation are more than satisfactory for reasonable confidence in performance of design basis functions under harsh environments. EQ-required calibration, replacement, and maintenance intervals can be maintained. However, the greatest savings occur from RISC-3 categorization when the level of treatment matches the lower safety significance of the application. The following subsections provide guidance on the relaxation of EQ constraints to levels appropriate for RISC-3 components.

## 6.2 Service Life Constraints

Under 10CFR50.69, the greatest savings occur if existing components that were previously qualified to 10CFR50.49 can be retained for RISC-3 service as long as possible with unnecessary special treatments eliminated. If a previously qualified component's remaining qualified life, as defined by the 10CFR50.49 program, equals or exceeds the remaining plant operating life, (including license renewal), efforts to establish a longer RISC-3 service life are unnecessary. However, if the existing qualified life is shorter than the expected remaining plant life, the basis of the qualified life and the capability of the component should be reviewed to determine if additional service life can be justified. Naturally, those components with the shortest replacement intervals should be reviewed first such that early savings may be accrued from application of the RISC process. Appendix D describes a number of techniques that may be used to determine if the service life of a RISC-3 component can be extended beyond the qualified life established when 10CFR50.49 is applied.

## 6.3 Relaxation of Maintenance, Calibration, and Inspection Constraints

In addition to remaining life considerations, other special treatment requirements—such as installation, maintenance, surveillance, calibration, and testing constraints—may be reduced or eliminated if reasonable confidence in accident functionality can still be retained. In the course of developing a 10CFR50.49 qualification basis, special calibration, maintenance, and subcomponent replacement requirements may have been generated to account for issues or artifacts from the accelerated aging portion of the qualification process. This section describes

these and related considerations. Figure 6-1 provides an overview of the review process for elimination of unnecessary programmatic constraints for RISC-3 components.

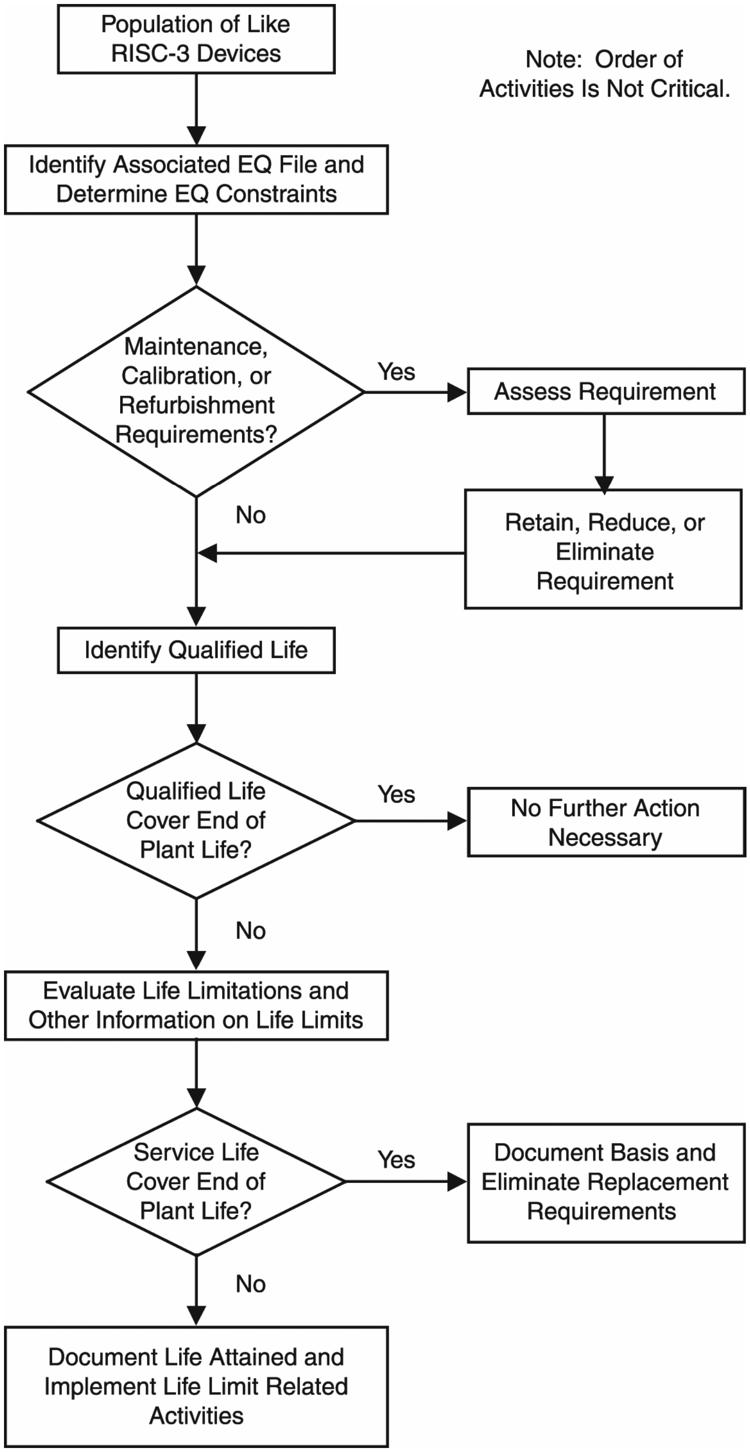


**Figure 6-1**
**EQ Constraint Relaxation Considerations**

Elimination of special treatment requirements does not mean that components will no longer be maintained, calibrated, or tested. Once the special treatment requirements are eliminated, normal station procedures for calibration, maintenance, and testing apply to the RISC-3 components. The treatment of the RISC-3 components will be commensurate with their low safety significance.

### 6.3.1 EQ Required Activities

As EQ files were developed, periodic activities were recognized as necessary to justify the continued qualification of components based on the available qualification data. Such activities included the following:

- Periodic replacement of age-sensitive subcomponents or even the entire component at a time-/temperature-dependent frequency
- Performance of specific periodic maintenance activities
- Performance of other surveillance-/maintenance-related activities, such as replacing seals every time a sealed cavity is opened
- Calibration of certain transmitters at specific calibration frequencies

Some of these activities were based on device limitations, often identified during implementation of the qualification program. Others were not based on device limitations but were prescribed to address methodology or testing limitations in the actual test program during the qualification program. For example, most EQs exposed the test specimen to accelerated thermal aging. The length of the accelerated thermal aging period and the temperature used in the simulation and material activation energy values dictate the service periods and temperatures that may be applied in the plant. These limitations in the use of the device are directly related to how the test program was performed. Requirements for the replacement of seals every time a cover is removed from a transmitter may exist because a simulation of opening and closing a transmitter's cover was not performed during a test program. Accordingly, the conservative EQ position is that information allowing the reuse of the cover gasket does not exist from the EQ test program; therefore, the gasket must be replaced at each opening of the cavity. Depending on the design of the gasket system, this may or may not be necessary to ensure a seal under accident conditions. The list of activities that are derived from the EQ test program to ensure functionality or eliminate concerns related to the components became known as *EQ-required activities*. When an EQ component is categorized as RISC-3, many of these EQ-required activities will no longer be necessary to establish reasonable confidence in the performance of accident function.

### 6.3.2 Recommended Activities

Some qualification programs include recommended activities that are based on manufacturers' recommendations or experience but are not directly derived from the qualification program or resolution of an anomaly in the EQ program. Although such activities may seem desirable, many of these recommendations have no direct effect on accident functionality and are therefore not applicable to RISC-3 accident functions. Examples of recommended activities include periodic

maintenance, such as cleaning surfaces and performing invasive inspections, described in the manufacturer's general literature. Unless this maintenance is specifically intended to resolve aging concerns not simulated in the test program or required by the manufacturer's EQ, the activity should not be considered an EQ-required activity. Such recommendations may have been entered into EQ files in a conservative effort to include all vendor recommendations as EQ program requirements. Once in EQ files, these recommendations were subject to strict implementation. Many utilities have reviewed their EQ files and eliminated these non-EQ-related recommendations from the EQ-required activities. If such an activity has not taken place, these non-EQ-related activities can be eliminated for RISC-3 harsh environment applications.

### 6.3.3 Calibration Requirements

Some electronic transmitters experienced significant calibration shifts during qualification test program thermal aging or radiation exposures. The manufacturer compensated for these shifts by requiring periodic calibration at intervals shorter than would otherwise be specified, based on the availability considerations used to establish Technical Specification surveillance/calibration intervals. Generally, these shifts are test artifacts due to high artificial aging temperatures and radiation simulation dose rates. Many utilities have eliminated these EQ-driven calibrations, based on operating experience (for example, as-found and as-left calibration data) or other data. If this elimination has not taken place, these EQ-driven calibrations should be eliminated for RISC-3 harsh environment applications. Under the constraints of reasonable confidence, elimination of the requirement to perform these EQ-driven calibrations is reasonable because the likely cause of the shift was the test regimen rather than from a cause that would be experienced in actual service. After EQ-required calibration has been eliminated, normal plant calibration practices should be used, and calibration frequencies related to expected drift or industry experience may be used. Similar considerations could apply to other electronic devices such as current-to-pressure (I/P) transducers as well as radiation monitors, which may have EQ-required calibration requirements.

When EQ constraints are eliminated, the licensee may find that plant Technical Specification requirements for calibration and surveillance become constraining. Accordingly, a Technical Specification amendment may be necessary to achieve calibration frequencies appropriate for RISC-3 instruments. In addition, changes to calibration and surveillance frequency for RISC-3 components may be affected by NRC staff and the industry efforts to implement risk-informed improvements to Technical Specifications. These improvements, or initiatives, are intended to maintain or improve safety while reducing unnecessary burden and to bring Technical Specifications into congruence with the NRC's other risk-informed regulatory requirements.

### 6.3.4 Configuration Constraints

Configuration constraints contained in EQ files may be overly conservative for some RISC-3 applications. Although there is no gain to changing installed devices, the use of alternate configurations may be possible at times of scheduled replacement or when new installations of similar devices occur. For example, conduit sealing, which may be necessary for inside-containment applications, could be eliminated or a lesser seal used for low-pressure HELB conditions. Prescriptive application methods for electrical splices using tape or heat shrink products may similarly be relaxed if the required accident conditions are significantly less severe that the tested conditions. Similarly, housing drains or pressure relief fitting necessitated by the severe steam environment associated with inside-containment LOCA conditions may be unnecessary for certain HELB environments. Orientation limitations based on the tested orientation may also not be necessary for RISC-3 applications

# 7 CONCLUSIONS

The implementation of risk-informed safety classification represents a significant departure from past practices. The RISC-3 category (safety related, low safety significance) allows RISC-3 components to be treated with a level of effort commensurate with their low safety significance. Less expensive components with less documentation may be used. The choice and treatment of these components will not include the highly prescriptive treatment that is required for safety-related, risk-significant components. Good engineering practices form the basis of treatment for RISC-3 components. Components will be assessed with respect to the environments that apply with a lower degree of conservatism. The options for the bases of RISC-3 accident function assessments are much broader than those allowed for risk-significant components, and the reduction in the required degree of conservatism will allow more cost-effective options for procurement and treatment.

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2. 10CFR50.49, *Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants*, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, D.C.
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# A
# MATERIAL CAPABILITIES INFORMATION

This appendix provides information that may be of use in preparing accident function assessments. It is not meant to be an exhaustive source of information but rather is provided to cover key issues and concerns. Numerous industry databases exist that contain thermal and radiation exposure data, and the information from those databases is not replicated here.

## A.1 Thermoplastics

Thermoplastic materials are melted to allow molding into a useful shape, and, if they contain no fillers or modifiers, thermoplastics will soften again when subjected to elevated temperatures. As they approach their melt temperature, thermoplastics will soften and lose their shape and structural integrity. Some devices with molded plastic bodies use thermoplastic materials that have melt points well above normal operating temperatures but below the higher temperatures associated with accidents, for example, peak steam accident (including high-energy line break [HELB] conditions). Table A-1 provides typical melt points for some common thermoplastic materials. Many of these materials may be supplied with reinforcing fillers such as fiberglass. The reinforced polymer may be used to higher temperatures as indicated by Column 5 of the table. The recommended use limits are 30°F lower than the associate melting points [11].

**Table A-1**
**Melt Points for Common Thermoplastic Materials**

| Material | Unreinforced Melt Point (°F) | Unreinforced Recommended Use Limit (°F) | Reinforced Melt Point (°F) | Reinforced Recommended Use Limit (°F) |
|---|---|---|---|---|
| ABS | 195 | 165 | 220 | 190 |
| Acetal | 230 | 200 | 325 | 295 |
| Nylon 6 | 167 | 137 | 420 | 390 |
| Nylon 6.6 | 160 | 130 | 490 | 460 |
| Nylon 6/12 | 194 | 164 | 415 | 385 |
| Polycarbonate | 265 | 235 | 300 | 270 |
| Polyethylene (HD) | 120 | — | 260 | 230 |
| Polypropylene | 135 | Not recommended | 295 | 265 |

Components molded of acrylonitrile butadiene styrene (ABS) should not be exposed to HELBs for significant durations above 212°F even if reinforced. Only reinforced nylon components should be used if HELB or loss-of-coolant accident (LOCA) exposures are possible. The peak and duration of accident conditions should be considered for acetal (for example, Delrin), polycarbonate (for example, Lexan), and polypropylene.

If the melt point for thermoplastic materials is found acceptable, degradation from thermal and radiation environments may be assessed to determine the possible length of use.

If thermoplastic materials are identified in a component and the accident environment temperature approaches or exceeds the recommended usage limit, the manufacturer should be consulted to determine if information is available concerning acceptable operation of the component at the accident temperature. If there is no such information, an operability test at the accident temperature may be performed or an alternate material or component should be sought and assessed.

## A.2 General Component Temperature Limits

Table A-2 provides estimated temperatures at which components would tend to fail if held for 8 hours [13]. This table provides insights on the durability of components under accident conditions. It may be used as a basis for showing reasonable confidence that components exposed to lower temperatures for shorter durations are not likely to fail. For example, based on this information, a motor exposed to 200°F for 1/2 hour is unlikely to fail. Some components can adequately function at temperatures and for durations that exceed those listed in Table A-2 (for example, when exposed to qualification test conditions).

**Table A-2**
**Upper Temperature Limits of Various Components**

| Component Type | Estimated Failure Temperature (°F for About 8 Hours) |
|---|---|
| Batteries | 200 |
| Battery chargers/inverters | 150 |
| Cables | 300 |
| Controllers | 150–200 |
| Distribution panels | 200–250 |
| Electromechanical relays | 300 |
| Indicating lights | 200–250 |
| Limit switches | 250 |
| Logic equipment | 150–200 |

**Table A-2 (cont.)**
**Upper Temperature Limits of Various Components**

| Component Type | Estimated Failure Temperature (°F for About 8 Hours) |
|---|---|
| Meters | 250 |
| Motor control centers | 200–250 |
| Motors | 200–250 |
| Power supplies | 150–200 |
| Pressure switches | 250–300 |
| Recorders | 150–200 |
| Solenoid valves | 250 |
| Solid-state relays | 150–200 |
| Switches | 250 |
| Temperature switches | 200–250 |
| Terminal blocks | 300 |
| Thermocouples/resistance temperature detectors (RTDs) | 300 |
| Transformers | 200–250 |
| Transmitters | 150–200 |
| Valve operators | 250–300 |

## A.3 General Radiation Capabilities of Materials

Figures A-1 through A-5 are from the EPRI report *Radiation Data for Design and Qualification of Nuclear Plant Equipment* (NP-4172SP) and provide guidance on the expected radiation capabilities of common organic insulators, elastomers, and lubricants [12]. Elongation-at-break and tensile strength are two key mechanical properties of insulators and elastomers that indicate the suitability of materials for thermal and radiation exposures. The figures show the levels of radiation at which damage begins to be detectable through the point at which a 25% loss of capability has been identified. The figures may be used to show radiation levels at which there is little concern for common engineering materials.

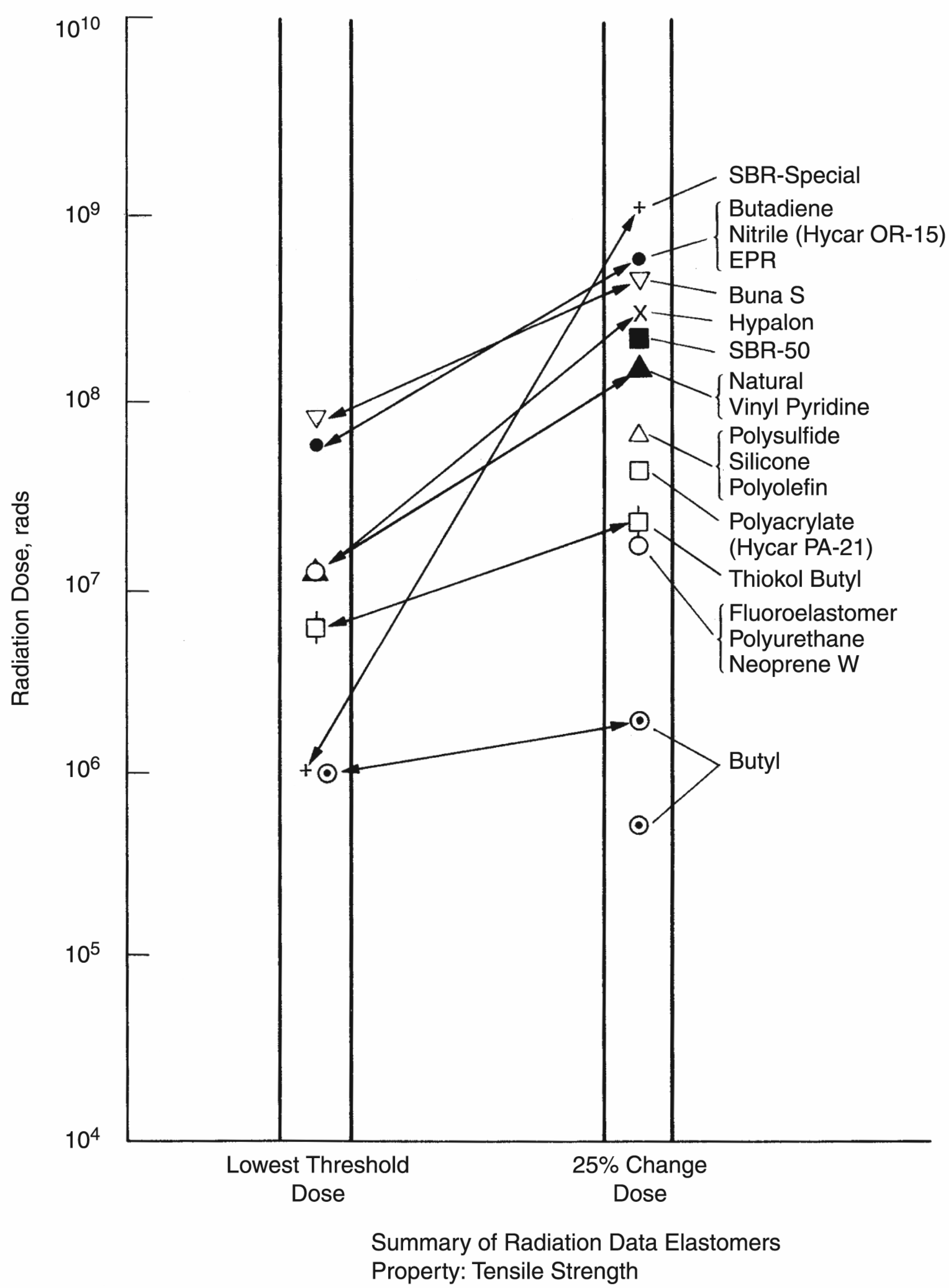


**Figure A-1**
**Radiation Capability of Elastomers: Tensile Strength**

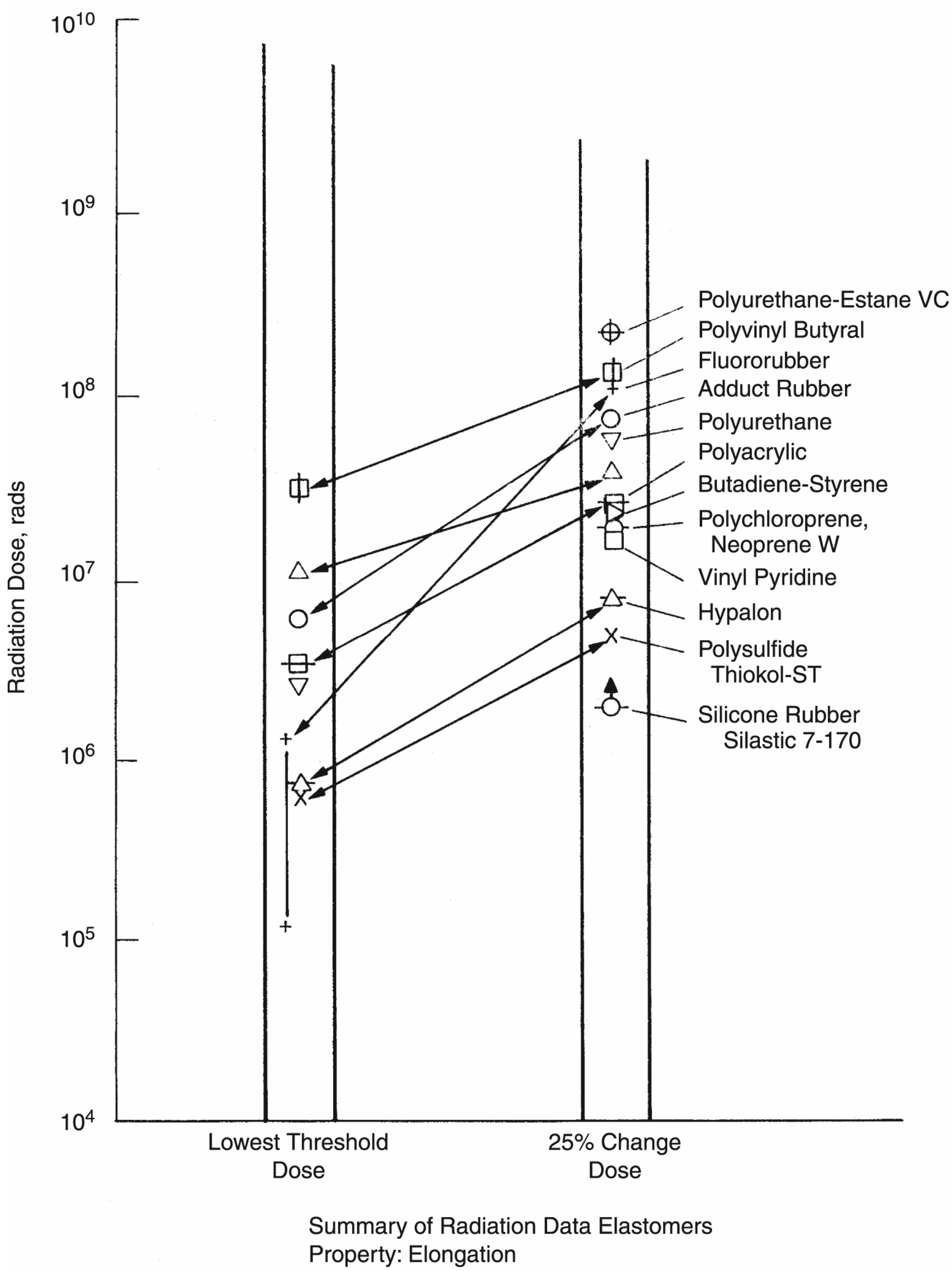


**Figure A-2**
**Radiation Capability of Elastomers: Elongation-at-Break**

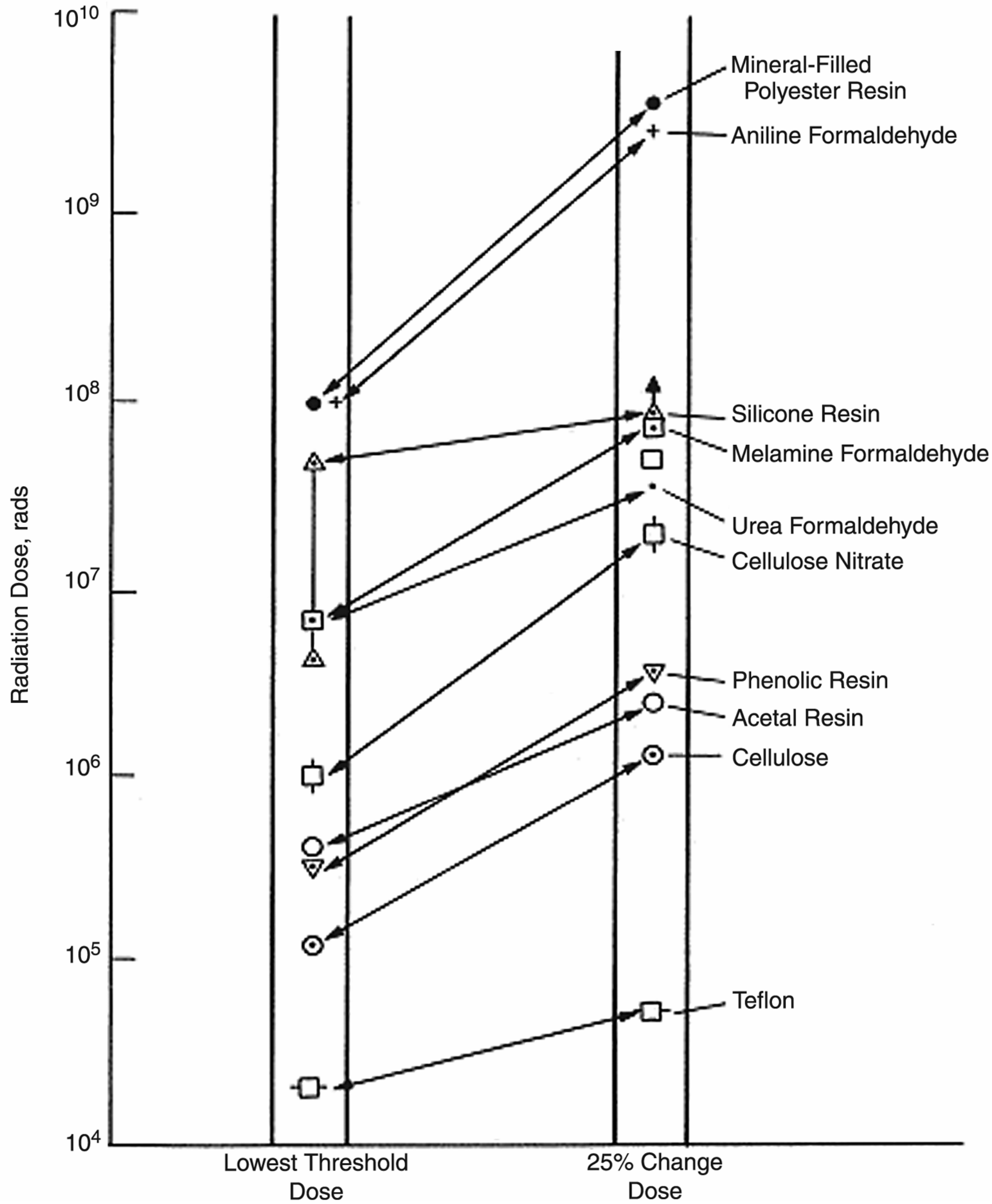


**Figure A-3**
**Summary of Radiation Data for Insulators: Tensile Strength**

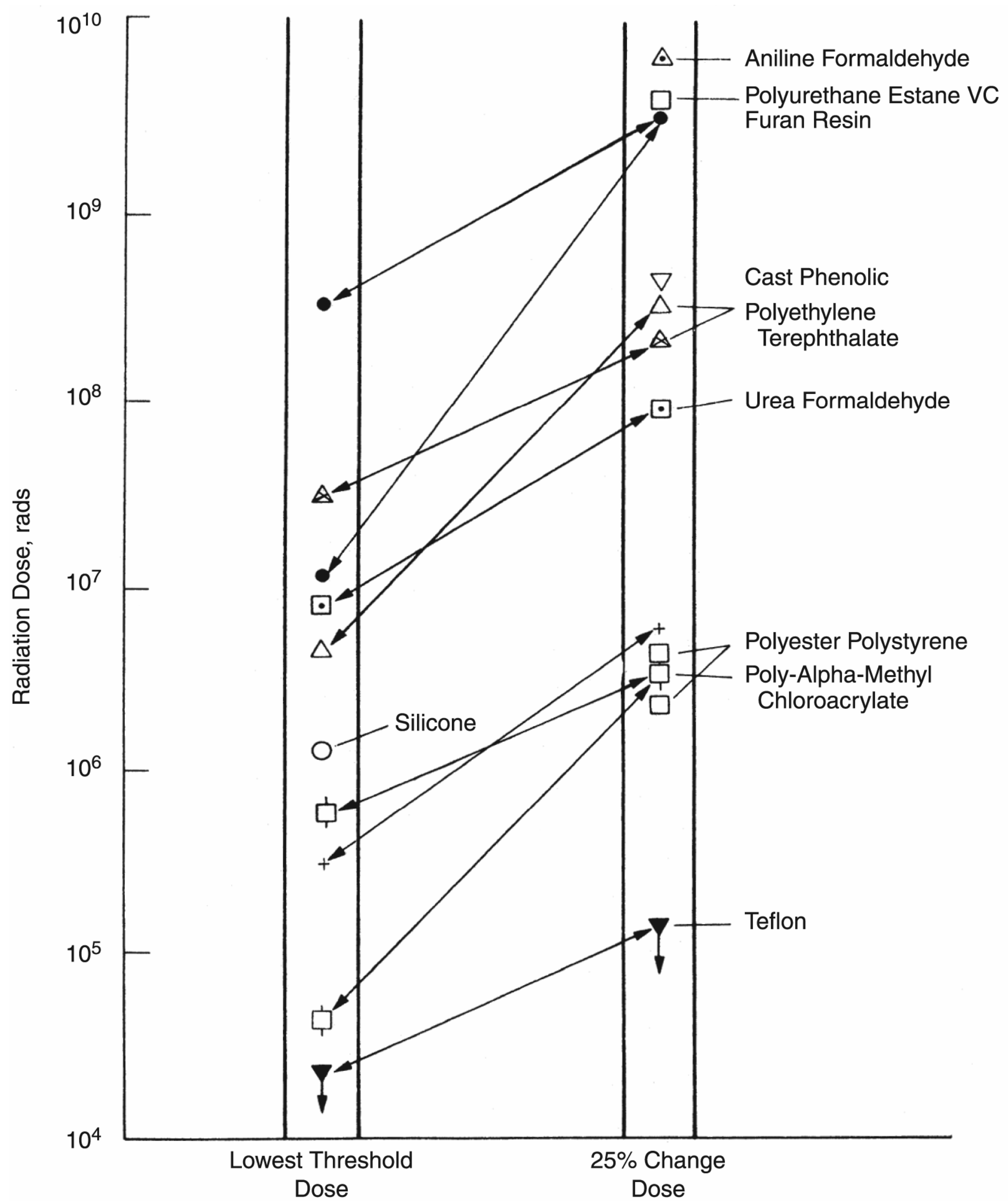


**Figure A-4**
**Summary of Radiation Data for Insulators: Elongation-at-Break**

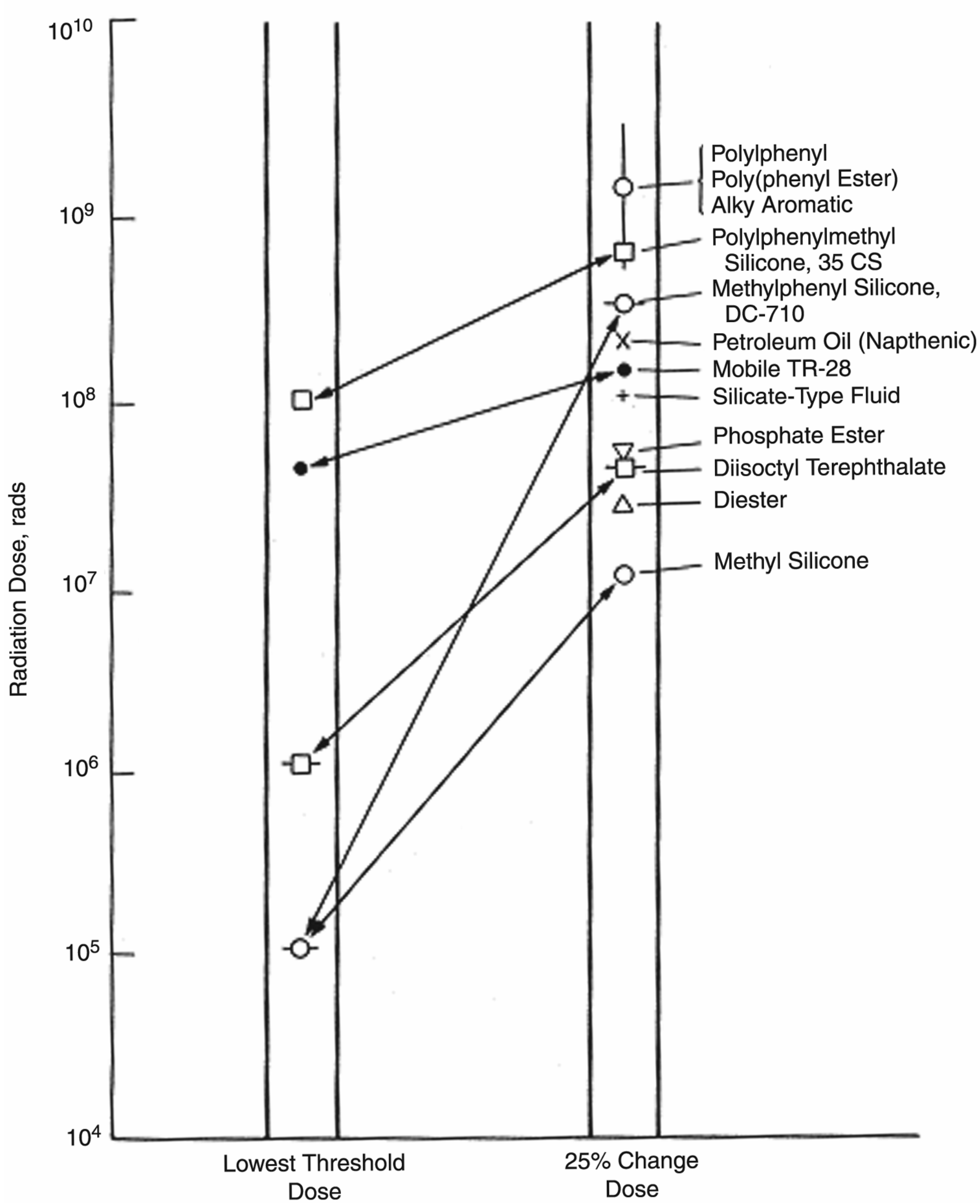


**Figure A-5**
**Summary of Radiation Data for Lubricants: Viscosity**

According to Figure A-3, below 100 Krads, only Teflon is a significant concern. Between 100 Krads and 1 Mrd, cellulose—which is rarely used in devices used in nuclear plants—becomes a concern, and acetal resin (for example, Delrin) is becoming a concern. More detailed radiation information on these and other materials is contained in the EPRI report *Radiation Data for Design and Qualification of Nuclear Plant Equipment* (NP-4172SP) [12] and industry databases.

## A.4 10- and N-Degree Rule Discussions

Section 4.5 of the EPRI report *A Review of Equipment Aging Theory and Technology* (NP-1558) describes the equivalency of the 10-degree and N-degree C rule to the Arrhenius model for thermal aging [14]. The 10-degree C rule indicates that, for each 10-degree C increase in temperature, the aging rate of a material doubles. In reality, this aging rule is conservative for most of the materials used in safety-related equipment because it is comparable to an activation energy of approximately 0.8–0.86 eV when extrapolating from an accelerated aging temperature,[13] which indicates a material that is fairly sensitive to thermal aging. Figure A-6 provides a comparison of the 10-degree C rule acceleration factors to those of the Arrhenius model (see Equation D-3).

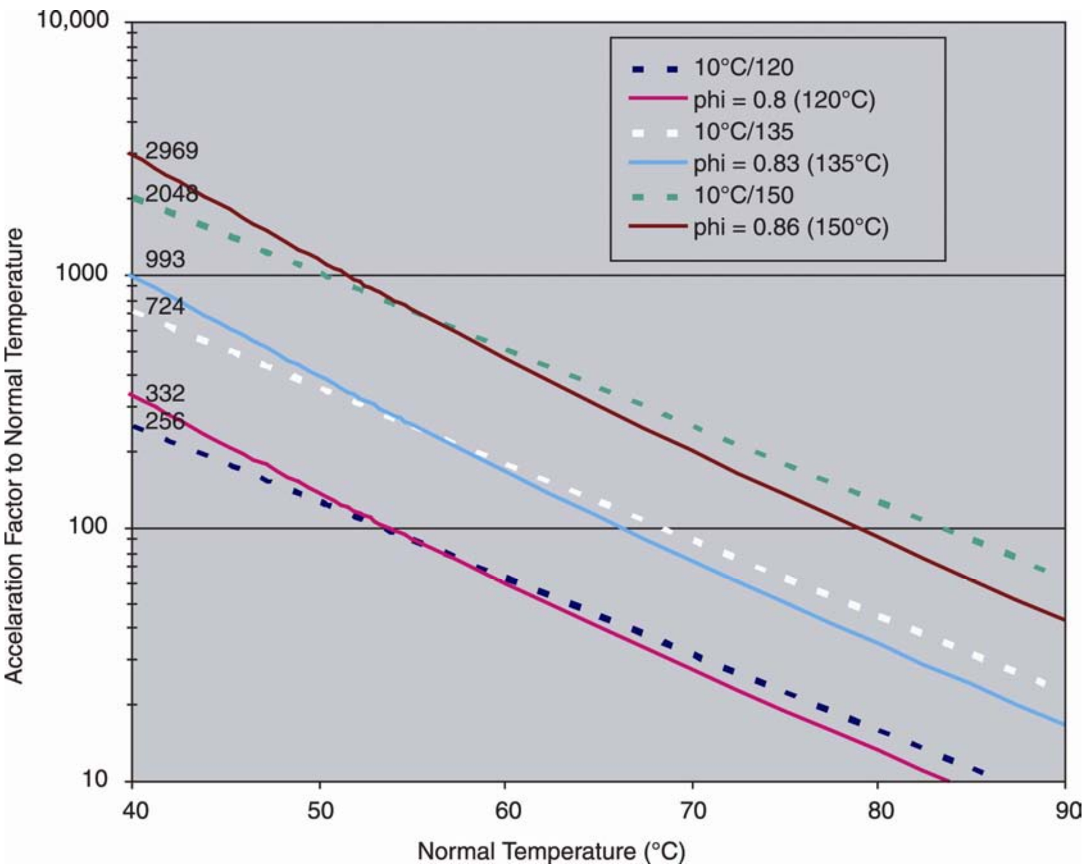


**Figure A-6**
**Comparison of 10-Degree C Rule to Arrhenius Model**

Figure A-6 indicates that, when the effects of 150°C aging to the range of 40–55°C are extrapolated, the 10-degree C rule is conservative in comparison to the Arrhenius model using an

[13] When extrapolating from a normal temperature to determine an accelerated aging temperature, the 10-degree C rule provides an equivalent of Arrhenius aging using 0.73 eV.

activation energy of 0.86 eV. At 40°C, the 10-degree C rule yields an acceleration factor of 2048, while the Arrhenius model with 0.86 eV activation energy yields an acceleration factor of 2969. Plots are also provided for 120 and 135°C aging temperatures.

The N-degree C rule uses other bases for acceleration. Figure A-7 provides a comparison of the 8-degree C rule to the Arrhenius model. The 8-degree C rule indicates that aging doubles for each 8-degree increase in temperature. For comparison of accelerated aging temperatures to normal temperatures, the 8-degree C rule compares to an activation energy of approximately 1 eV.

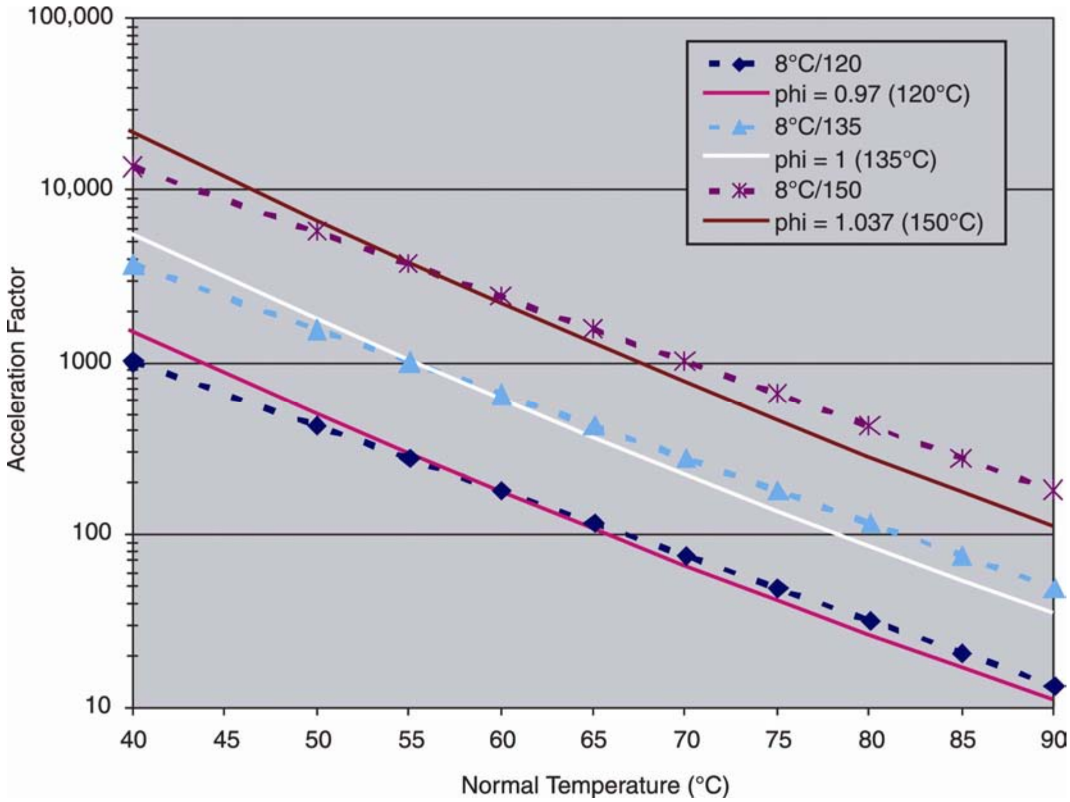


**Figure A-7**
**Comparison of 8-Degree C Rule to Arrhenius Model**

Most materials used in electrical components have an activation energy of at least 0.8 eV. Table A-3 contains a range of activation energies for typical materials, and Figure A-8 provides a histogram of the data from Table A-3. The histogram indicates that the bulk of the materials commonly used have activation energies above 0.8 eV. Although materials with lower activation energies could be used, manufacturers tend to not use such materials in commercial equipment because of their tendency to age more rapidly. Table A-3 and Figure A-8 are derived from Table A-7-1 from the EPRI report *Nuclear Power Plant Equipment Qualification Reference Manual* (TR-100516) [13]. Given that the bulk of common engineering materials have activation energies above 0.8 eV, reasonable confidence may be achieved by using the 10-degree C rule for nearly any application. The 8-degree C rule is conservative for most materials as well.

**Table A-3**
**Average Activation Energies for Common Materials and Subcomponents**

| Material Common Name | Average |
|---|---|
| Acetal | 0.90 |
| Alkyd | 1.52 |
| Butyl rubber | 1.29 |
| Capacitor | 0.79 |
| CMOS (complementary metal oxide semiconductor) (integrated circuit) | 1.12 |
| CSPE (chlorosulfonated polyethylene) | 1.24 |
| DAP (diallyl phthalate) | 1.76 |
| Dimethacrylate | 0.91 |
| Diode | 1.33 |
| EPDM (ethylene propylene diene monomer) | 1.36 |
| Epoxy | 1.19 |
| Epoxy and glass | 1.46 |
| Epoxy resin | 0.90 |
| EPR (ethylene propylene rubber) | 1.18 |
| EPR and Nomex | 1.18 |
| Fiberglass and acrylic | 1.15 |
| Fluoroelastomer | 1.17 |
| Germanium transistor | 1.07 |
| Kapton polyimide | 1.30 |
| LED (light-emitting diode) | 0.58 |
| Melamine (glass) | 1.59 |
| Motor insulation system | 0.96 |
| Mylar polyester | 1.18 |
| Neoprene | 1.00 |
| Nitrile rubber | 0.88 |
| Nomex (aramid paper) | 1.23 |
| Nylon | 1.00 |
| Nylon 11 | 1.23 |

**Table A-3 (cont.)**
**Average Activation Energies for Common Materials and Subcomponents**

| Material Common Name | Average |
|---|---|
| Nylon 6 | 1.24 |
| Nylon 6 and glass | 1.53 |
| Nylon 66 | 1.07 |
| Nylon 66 and glass | 1.81 |
| Nylon 66 and mineral | 0.74 |
| Operational amplifier | 0.98 |
| Phenolic | 1.05 |
| Phenolic (alkyd) | 1.01 |
| Phenolic (asbestos) | 0.95 |
| Phenolic (cellulose and mineral) | 0.91 |
| Phenolic (cellulose) | 1.10 |
| Phenolic (cotton) | 1.19 |
| Phenolic (glass) | 1.14 |
| Phenolic (mineral) | 1.01 |
| Phenolic (paper) | 1.10 |
| Phenolic GP (general purpose) | 1.17 |
| Phenolic resin | 1.02 |
| Polyacrylate and glass | 1.22 |
| Polyacrylate rubber | 0.94 |
| Polyamide | 1.18 |
| Polycarbonate | 1.18 |
| Polyester | 1.23 |
| Polyester (amide-imide) | 0.66 |
| Polyester (Dacron and glass) | 1.14 |
| Polyester (glass) | 1.42 |
| Polyester (imide) | 1.20 |
| Polyester (phenolic) | 1.20 |
| Polyester (polyamide-imide) | 1.38 |
| Polyethylene | 1.29 |

**Table A-3 (cont.)**
**Average Activation Energies for Common Materials and Subcomponents**

| Material Common Name | Average |
|---|---|
| Polyimide | 1.33 |
| Polyimide and glass | 0.87 |
| Polyolefin | 1.22 |
| Polypropylene | 1.14 |
| Polysulfone | 0.80 |
| Polyurethane | 1.05 |
| Polyurethane and nylon | 1.18 |
| Polyvinyl formal | 0.92 |
| PPS (polyphenylene sulfide) and glass | 0.99 |
| PST (polyester) | 1.83 |
| PVC (polyvinyl chloride) | 1.28 |
| PVC and glass | 1.18 |
| Resistor | 0.66 |
| RTV (silicone rubber adhesive) | 0.91 |
| Silicon transistor | 1.25 |
| Silicone | 1.28 |
| Silicone and glass | 1.04 |
| Silicone diode | 1.86 |
| Silicone enamel | 1.52 |
| Silicone resin | 0.60 |
| Silicone rubber | 1.22 |
| Silicone rubber and glass | 1.55 |
| Teflon | 1.74 |
| Tefzel | 1.00 |
| Transistor | 1.08 |
| XLPE (cross-linked polyethylene) | 1.24 |

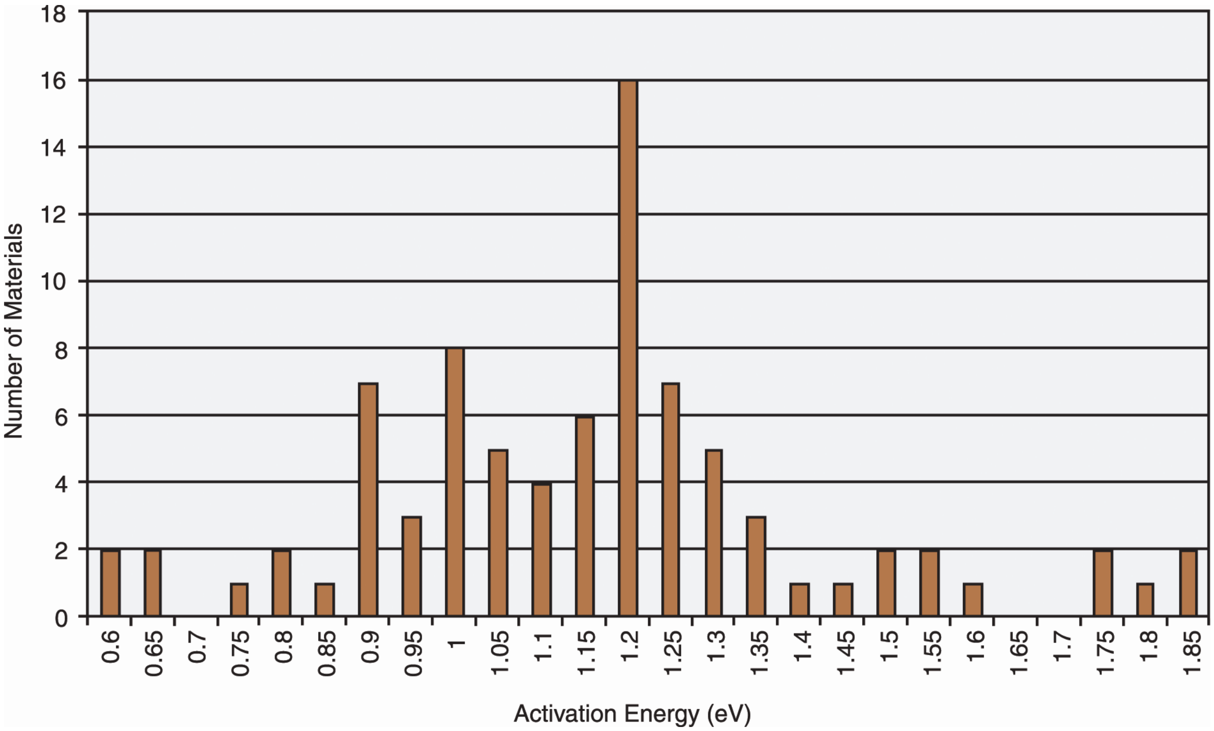


**Figure A-8**
**Histogram of Average Activation Energies**

# B
# TRANSMITTER HELB TEST

The report *Operability Test Report—Rosemount Model No. 1153db5pa Pressure Transmitter* is presented in this appendix [15]. It describes a high-energy line break (HELB) test of a Rosemount transmitter. The test was performed to determine if an unsealed transmitter was operable. The results showed that sealing of the electrical cavity was not important to operation even in the event of a severe HELB. The test was configured conservatively with the flexible conduit draining toward the transmitter. The connected junction box had numerous openings directly connected to the test chamber environment, and the flexible conduit for the transmitter was connected to the bottom of the junction box.

During the steam exposure, the output of the transmitter did not shift, and subsequent to the exposure, no indication was found that moisture had entered the terminal housing. The conclusion is that the steam compressed the dry air in the flexible conduit, keeping the terminations dry. The steam exposure heated the conduit relatively quickly, and condensation did not occur in the conduit.

# NUTHERM

# OPERABILITY TEST REPORT

## ROSEMOUNT MODEL NO. 1153DB5PA
## PRESSURE TRANSMITTER

Rev. 0: October 1, 2003

## REVISIONS

Revisions to this Operability Test Report are consistent with Nutherm International, Inc. policies. To delineate the exact location of a given revision, a vertical line is used on the right margin with the appropriate revision number. For a complete report rewrite, no vertical lines are used to indicate the revisions and the revision number is indicated at the top of each page.

## REVISION LOG

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# SUMMARY

This document was prepared to present the results of operability testing of a Rosemount Model No. 1153DB5PA Pressure Transmitter. The component that was tested is identified in Table 1.

Testing was performed in accordance with Nutherm operability test procedure number D-175P, Revision 0, contained in Attachment I. Operability testing demonstrates the ability of the equipment to function in the worst case in-service environment.

The test specimen successfully passed the electrical functionality and acceptance requirements. Inspection of the transmitter after the test showed no signs of moisture in any cavity and no discolorations nor water markings in the termination and electronics cavities. The testing and results are described below.

# TEST SPECIMEN

The equipment to be tested was assigned a Nutherm Test Laboratory (NTL) number at the start of the test program. A description of the test specimen, with its assigned NTL number, is presented in Table 1.

TABLE 1

TEST SPECIMEN INDEX

| NTL NO. | MANUFACTURER | PART NO. | DESCRIPTION |
|---|---|---|---|
| 6127 | Rosemount | 1153DB5PA | Differential Pressure Transmitter, 0-750 inch WC (calibrated as 0-500 WC) |

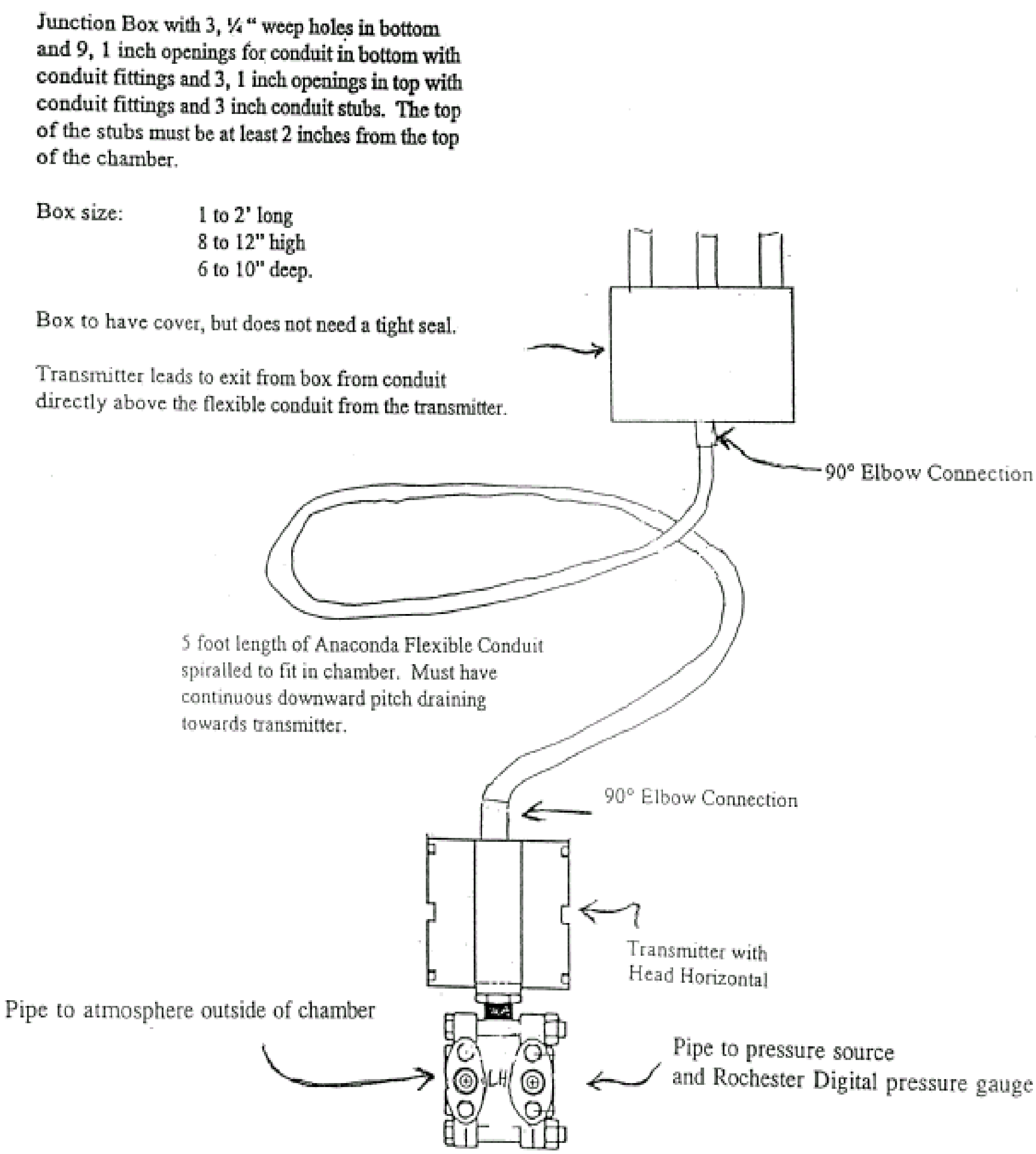
# SPECIMEN PREPARATION

The transmitter was calibrated for a span of 0-500 inches WC for a 4-20mA output.

The transmitter was fitted with flexible conduit and a junction box as shown in Figure 1. The configuration simulates a transmitter that is mounted five feet below the associated junction box with a flexible conduit running between the electrical port of the transmitter and the junction box. Because of chamber size constraints, the flexible conduit was configured in a downward spiral from the function box to the transmitter with a constant pitch towards the transmitter. This configuration simulated the condensing surface of the 5 foot vertical, flexible conduit length and caused the condensation to drain towards the transmitter. The conduit was not sealed at either end such that the electrical compartment of the transmitter was vented to atmosphere through the flexible conduit and junction box. The junction box used in the test had three short conduit segments in the top of the box that were open to atmosphere and nine conduit openings in the bottom of the box as well as three 1/4 inch weep holes. Eight of the nine conduit fittings had conduit

FIGURE 1

Layout of Equipment for Rosemount Transmitter Operability Test



couplings mounted in them but no conduits were in place. As such, the box had a large number of openings that would directly admit steam during the testing. The ninth bottom opening was connected to the flexible conduit for the transmitter. One of the top entry conduit stubs was located directly over the opening for the flexible conduit leading to the transmitter. The transmitter wires came through this opening and ran directly into the flexible conduit to allow any condensation on the wires to run directly into the flexible conduit rather than to drain off as would occur if the leads had been looped in the box.

The transmitter, conduit and junction box were placed in the test chamber. The low-pressure port of the transmitter was piped to atmosphere external to the chamber and the high-pressure port was piped to the pressure source and the pressure monitor.

Water sprays were placed in the chamber bottom for temperature quenching after the steam portion of the test and to assure high humidity during the remainder of the test.

# MONITORING AND POWERING

The transmitter output was monitored directly on a milliammeter. The pressure applied to the high pressure port was monitored via a digital pressure gauge. The pressure source was regulated nitrogen. A thermocouple was located approximately 2 inches from the transmitter body to monitor chamber temperature. The initial portion of the test profile was attained by use of saturated steam. Therefore, pressure was not monitored nor was humidity. Thereafter, the chamber was cooled by means of water spray. Cool air was admitted during the cooldown from 287°F. Thereafter, the chamber remained sealed. The water spray was continued to assure a high humidity condition through the remainder of the test period. The temperature during the 120°F portion of the profile was maintained by admitting saturated steam to the chamber.

Prior to the performance of the operability test, the transmitter's accuracy was determined at 0, 350, 400, and 450 inches WC as a baseline of the system when installed in the chamber.

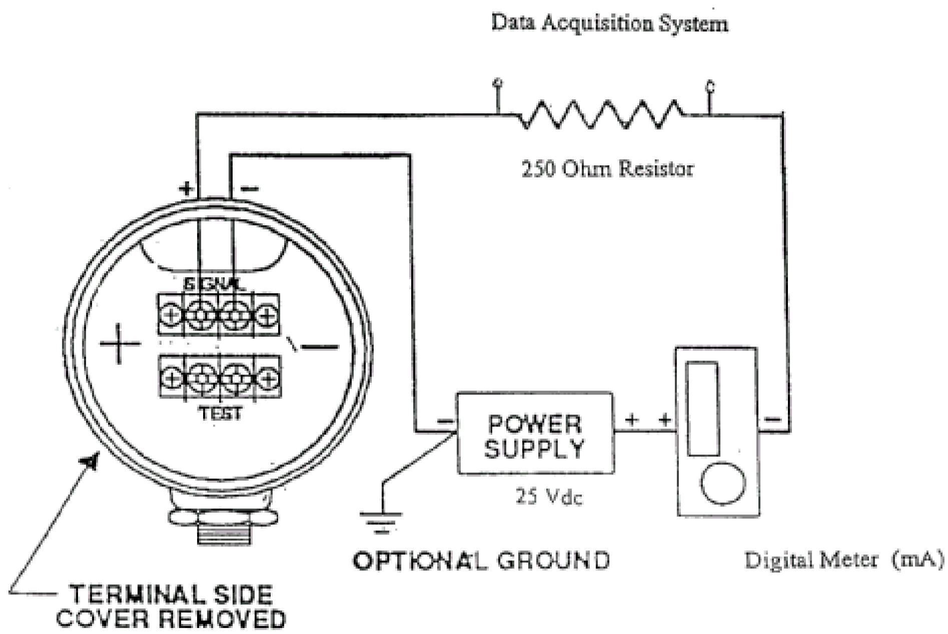
During the operability test, the transmitter loop was powered in accordance with Figure 2 for the entire operability test period.

At the start of the test and during periods when output tests were not being performed, the low pressure port was at atmospheric pressure external to the test chamber, and the high pressure port was pressurized to 450 inches WC. The transmitter output and the pressure monitor output were recorded every 60 seconds during the period from the start of the test through the end of the first 10 minutes from achieving the peak profile temperature. For the remainder of the first hour, the values were recorded every 10 minutes. Thereafter, the values were recorded every 15 minutes.

Once during the first 30 minutes, the output of the transmitter and the pressure monitor were recorded at 0, 350, 400, and 450 inches WC. This test was repeated at one hour elapsed time, and then at 3 hours elapsed time.

FIGURE 2

Test Circuit Electrical Layout




Note: Chamber Thermocouple shall be connected to the data acquisition system. The thermocouple shall be located approximately 2 inches from head of test specimen.

# ENVIRONMENTAL CONDITIONS AND MONITORING

The equipment was subjected to an environmental exposure test within a chamber. The chamber was heated using steam as the heat source. The drain of the chamber was closed during the first two minutes of the test causing a pressurized, saturated steam condition. Thereafter, the chamber drain remained open and steam was added as necessary to maintain the temperature profile. During the period following the first few minutes, water sprays operated in the chamber to help cool it and to maintain a high humidity condition. These conditions assured that condensation would occur within the junction box, conduit and transmitter to the extent that they would occur under the hypothesized plant conditions. Table 2 provides the plant profile including a 15°F margin on the peak as required by IEEE Std. 323-1974.

Table 3 shows the temperature recordings for the test. Figure 3 is the graph of those recordings.

TABLE 2

ENVIRONMENTAL CONDITIONS

| Period | Temperature, °F Maximum | Temperature, °F Target | Actual, °F |
|---|---|---|---|
| Start | | Room ambient | 68.8 |
| 15 s. (Best Effort) | - | Ramp to 257 | 257 (70 s. ET) |
| 15 to 30 s (Best Effort) | - | Ramp to 285 | 285 (100 s. ET) |
| 30 to 60 s | - | 285 | 286.2 |
| 30 to 75 s | - | Ramp to 224[2] | 283.9 |
| 75 to 90 s | - | Ramp to 194[2] | 287.8 |
| 90 to 100 s | - | Ramp to 185[2] | 284.8 |
| 100 to 350 s | - | Ramp to 124[2] | 219.8 |
| 350 s to 3 hours | 130 | 120 | 123.3[1] |

Note 1: The chamber temperature ramped from 219.8°F at 350 seconds to 150°F at approximately 18 minutes elapsed time and then to 128°F at 31 minutes. Thereafter, the temperature ranged from 123.3 to 129.1°F. High humidity conditions were maintained. The duration and high humidity conditions for the test were selected to determine if the high humidity condition in the chamber would adversely affect the accuracy of a transmitter with an unsealed electrical housing (i.e., a housing having a vertical 5 foot flexible conduit connected to it with no seal the junction box).

The environmental conditions within the chamber were monitored during the test via a thermocouple installed inside the chamber. The output of the thermocouple was monitored and recorded using a calibrated data acquisition system.

# TABLE 3

Table 3. 1153DB5PA Rosemount Accuracy
Under Steam and High Humidity Conditions

| Time, minutes | Transmitter mA | Rochester Pressure | Transmitter | Difference, inches WC | Acceptance, inches WC | Difference as % of Span | Acceptance as % of Span | Temperature, °F | Pressure, psig |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 18.873 | 473.9 | 464.8 | -9.1 | ± 12 | -1.8 | ± 2.5 | 68.8 | 0 |
| 1 | 18.464 | 443.5 | 452.0 | 8.5 | ± 12 | 1.7 | ± 2.5 | 242.5 | 11.3 |
| 2 | 18.275 | 442.8 | 446.1 | 3.3 | ± 12 | 0.7 | ± 2.5 | 286.7 | 41.3 |
| 3 | 18.415 | 443.5 | 450.5 | 7.0 | ± 12 | 1.4 | ± 2.5 | 286.4 | 0 |
| 4 | 18.192 | 442.3 | 443.5 | 1.2 | ± 12 | 0.2 | ± 2.5 | 244.7 | 0 |
| 5 | 18.203 | 442.0 | 443.8 | 1.8 | ± 12 | 0.4 | ± 2.5 | 227.0 | 0 |
| 6 | 18.203 | 441.1 | 443.8 | 2.7 | ± 12 | 0.5 | ± 2.5 | 227.9 | 0 |
| 7 | 18.2 | 440.9 | 443.8 | 2.9 | ± 12 | 0.6 | ± 2.5 | 230.9 | 0 |
| 8 | 18.177 | 439.9 | 443.0 | 3.1 | ± 12 | 0.6 | ± 2.5 | 233.3 | 0 |
| 9 | 18.195 | 439.9 | 443.6 | 3.7 | ± 12 | 0.7 | ± 2.5 | 214.2 | 0 |
| 10 | 18.191 | 439.2 | 443.5 | 4.3 | ± 12 | 0.9 | ± 2.5 | 210.4 | 0 |
| 12 | | | | | | | | 197.7 | 0 |
| 14 | | | | | | | | 192.3 | 0 |
| 16 | | | | | | | | 176.0 | 0 |
| 18 | | | | | | | | 149.9 | 0 |
| 20 | 18.117 | 436.0 | 441.2 | 5.2 | ± 12 | 1.0 | ± 2.5 | 144.6 | 0 |
| | 4.2067 | 0.0 | 6.5 | 6.5 | ± 12 | 1.3 | ± 2.5 | | |
| | 15.348 | 350.1 | 354.6 | 4.5 | ± 12 | 0.9 | ± 2.5 | | |
| | 16.952 | 400.9 | 404.8 | 3.9 | ± 12 | 0.8 | ± 2.5 | | |
| | 18.522 | 450.4 | 453.8 | 3.4 | ± 12 | 0.7 | ± 2.5 | | |
| 30 | 18.524 | 450.0 | 453.9 | 3.9 | ± 12 | 0.8 | ± 2.5 | 125.5 | 0 |
| 40 | 18.514 | 450.2 | 453.6 | 3.4 | ± 12 | 0.7 | ± 2.5 | 145.0 | 0 |
| 50 | 18.464 | 449.6 | 452.0 | 2.4 | ± 12 | 0.5 | ± 2.5 | 126.2 | 0 |
| 60 | 18.434 | 448.2 | 451.1 | 2.9 | ± 12 | 0.6 | ± 2.5 | 127.1 | 0 |
| 65 | 18.471 | 448.1 | 452.2 | 4.1 | ± 12 | 0.8 | ± 2.5 | 126.0 | 0 |
| | 4.1574 | 0.3 | 4.9 | 4.6 | ± 12 | 0.9 | ± 2.5 | | |
| | 15.373 | 351.6 | 355.4 | 3.8 | ± 12 | 0.8 | ± 2.5 | | |
| | 16.936 | 400.3 | 404.3 | 3.9 | ± 12 | 0.8 | ± 2.5 | | |
| | 18.508 | 449.6 | 453.4 | 3.8 | ± 12 | 0.8 | ± 2.5 | | |
| 70 | 18.585 | 451.8 | 455.8 | 4.0 | ± 12 | 0.8 | ± 2.5 | 129.1 | 0 |
| 75 | 18.496 | 449.2 | 453.0 | 3.8 | ± 12 | 0.8 | ± 2.5 | 127.1 | 0 |
| 90 | 18.546 | 450.7 | 454.6 | 3.9 | ± 12 | 0.8 | ± 2.5 | 124.6 | 0 |
| 105 | 18.515 | 449.8 | 453.6 | 3.8 | ± 12 | 0.8 | ± 2.5 | 125.3 | 0 |
| 120 | 18.497 | 449.3 | 453.0 | 3.7 | ± 12 | 0.7 | ± 2.5 | 123.3 | 0 |
| 135 | 18.474 | 448.7 | 452.3 | 3.6 | ± 12 | 0.7 | ± 2.5 | 123.5 | 0 |
| 150 | 18.535 | 450.9 | 454.2 | 3.3 | ± 12 | 0.7 | ± 2.5 | 124.0 | 0 |
| 165 | 18.521 | 450.5 | 453.8 | 3.3 | ± 12 | 0.7 | ± 2.5 | 124.8 | 0 |
| 180 | 18.516 | 450.7 | 453.6 | 2.9 | ± 12 | 0.6 | ± 2.5 | 123.7 | 0 |
| | 4.1424 | 0.8 | 4.5 | 3.7 | ± 12 | 0.7 | ± 2.5 | 123.3 | 0 |
| | 15.318 | 350.8 | 353.7 | 2.9 | ± 12 | 0.6 | ± 2.5 | | |
| | 16.902 | 400.2 | 403.2 | 3.0 | ± 12 | 0.6 | ± 2.5 | | |
| | 18.511 | 450.6 | 453.5 | 2.9 | ± 12 | 0.6 | ± 2.5 | | |

FIGURE 3.a

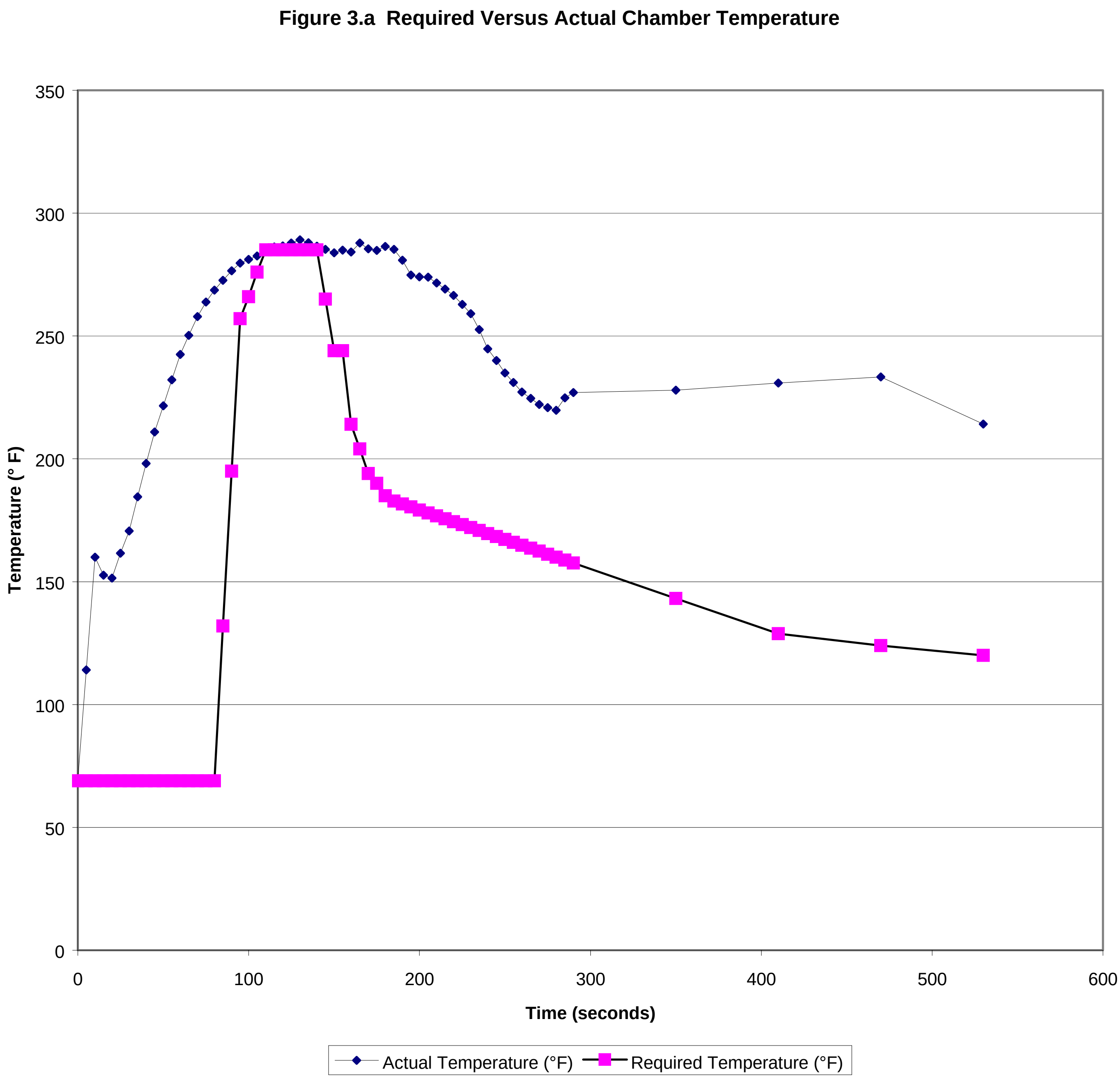
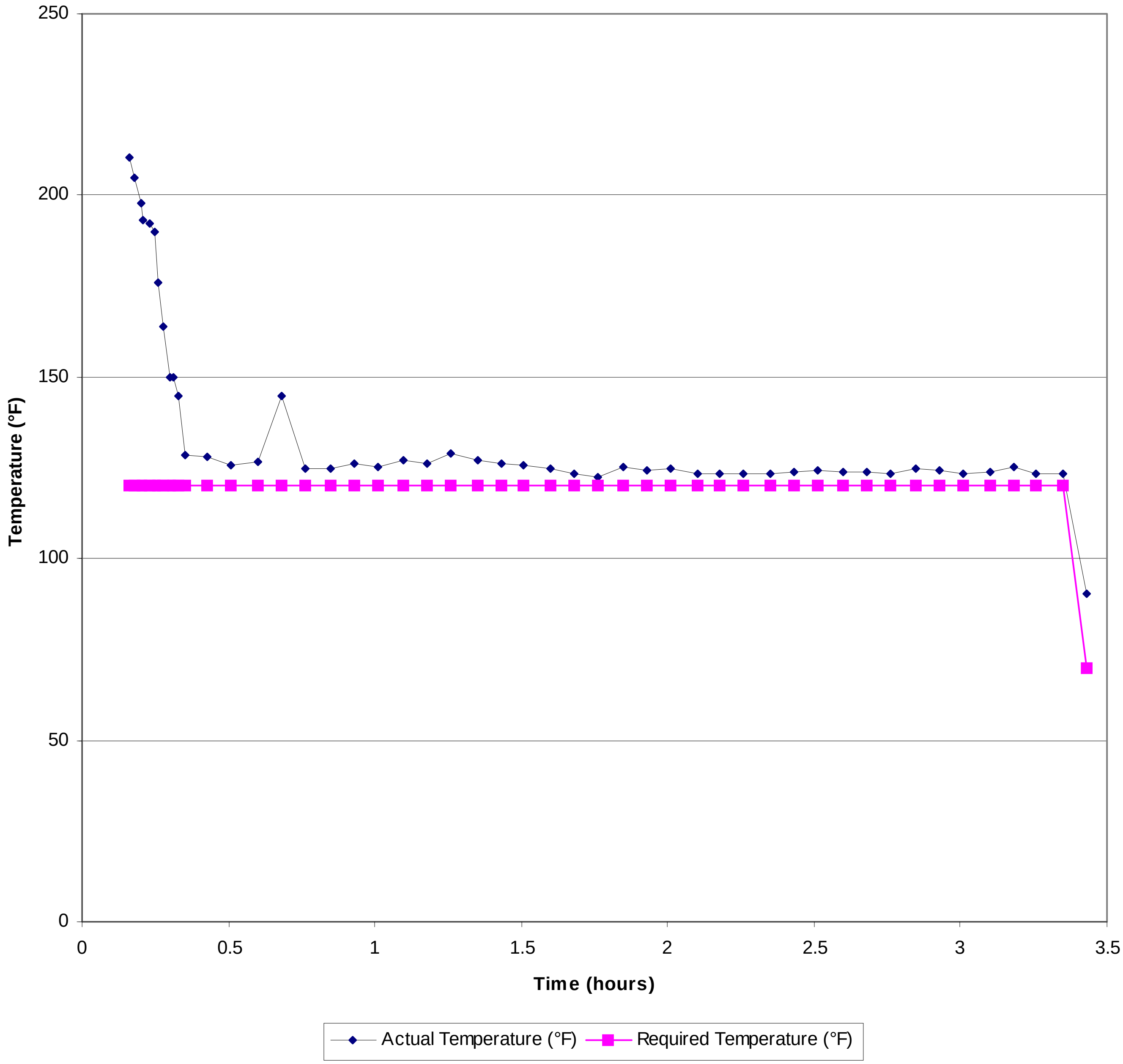


Figure 3.a Required Versus Actual Chamber Temperature
350
300
250
200
150
100
50
0
Temperature (° F)
0
100
200
300
400
500
600
Time (seconds)
Actual Temperature (°F)
Required Temperature (°F)

FIGURE 3.b

**Figure 3.b Required Versus Actual Chamber Temperature**



# TEST EVENTS AND RESULTS

## TEST EVENTS

The test specimen was verified as being operational within the test chamber by confirming accuracy at 0, 350, 400, and 450 inches WC prior to the start of the steam test.

The chamber was closed and the steam test was begun at 9:01 am on February 20, 1997. Best efforts to achieve the transient were made and the peak profile temperature was achieved within 2 minutes. Thereafter, the start of each profile segment was shifted to assure conservatism. The profile achieved is compared to a shifted requirements profile in Figure 3. (The data for Figure 3 is contained in Attachment 3.)

As can be seen from Figure 3, the high temperature section of the profile enveloped the peak required temperature condition and was much longer in duration. At approximately 180 seconds elapsed time, the steam supply was discontinued and water spray was started to cool the chamber and assure a high humidity condition.

During the first 10 minutes, transmitter output and actual pressure were measured every minute. The measurements were made every 10 minutes thereafter for the next 50 minutes and then every 15 minutes thereafter. At approximately 20 minutes into the test, an operational test was performed to determine the accuracy of the transmitter at 0, 350, 400, and 450 inches WC. This test was repeated at the one hour mark and at the conclusion of the test.

## TEST RESULTS

Review of the transmitter output versus recorded temperature for all measurements shows that the transmitter met the accuracy requirement of ± 2.5% of span for all measurements. The loop error range for the entire test was –1.8 to 1.3%, which was well within the requirement. The accuracy data with temperatures and pressure conditions are shown in Table 3.

When the chamber was opened at the conclusion of the test, moisture was noted on the exterior of the transmitter end bells. However, when the end bell of the electrical terminations and electronics cavity were removed, there was no moisture present nor signs of moisture inside the cavities (i.e., no discolorations or water rings).

# RESULTS AND RECOMMENDATIONS

The results and recommendations presented here are based upon the observed operation of the equipment at the applied environmental conditions during the test.

The environmental conditions applied to the specimen enveloped the requirements of the procedure.

The test specimen maintained the required accuracy throughout the duration of the steam and high humidity test even through the electrical cavity was ported to the chamber environment via the flexible conduit  The test conditions were highly conservative in that the hypothesized plant conditions are superheated with less than 1 psig pressure at 270°F, while the test chamber had a saturated steam condition of 41 psig at 286°F.  The conditions assured that steam would be forced into the electrical housing if it would occur in the actual condition.  These conservative conditions had no discernible effect on the transmitter output and showed no signs of an adverse trend.

The test complements the qualification of 1153 D Rosemount transmitters that was performed by the manufacturer for elevated temperatures in a sealed state.

# ATTACHMENT I

# OPERABILITY PROCEDURE D-175P

# ROSEMOUNT MODEL NO. 1153DB5PA PRESSURE TRANSMITTER

REV. 0: February 18, 1997

## REVISIONS

Revisions to this Operability Test Report are consistent with Nutherm International, Inc. policies. To delineate the exact location of a given revision, a vertical line is used on the right margin with the appropriate revision number. For a complete procedure rewrite, no vertical lines are used to indicate the revisions and the revision number is indicated at the top of each page.

REVISION LOG

| REVISION | PAGE | SECTION | REFERENCE |
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## 1.0 SCOPE

Operability testing will be performed to demonstrate the ability of the equipment to function while in the worst case in-service environment. The operability test will expose the equipment to this environment, while the equipment is under electrical load. The following sections provide instructions for the performance of the operability test.

## 2.0 TEST SPECIMENS

The equipment to be tested was assigned a Nutherm Test Laboratory (NTL) number at the start of the qualification test program. A description of the test specimens, with their assigned NTL numbers, is presented in Table 1.

TABLE 1
TEST SPECIMEN INDEX

| NTL NO. | MANUFACTURER | PART NO. | DESCRIPTION |
|---|---|---|---|
| 6127 | Rosemount | 1153DB5PA | Pressure Transmitter |

## 3.0 ELECTRICAL APPLICATION AND MONITORING

### 3.1 Preparation and Mounting

The transmitter will be mounted to the bracket provided with the bolts provided. The bolts will be torqued "snug" tight.

The transmitter shall be fitted with flexible conduit and a junction box per Figure 1. Then the transmitter will be placed in the test chamber and low-pressure port piped to atmosphere external to the chamber and the high-pressure port piped to the pressure source and the pressure monitor.

The device shall be wired in accordance with electrical test circuit as contained in Figure 2. The transmitter leads will pass through the flexible conduit, then directly through the junction box and out of the conduit fitting directly above the flexible conduit port. The length of additional wire between the conduit fitting and the chamber penetration shall be minimized to assure that the effect of the accident environment is measured on the segment of cable between the junction box and the transmitter and the transmitter terminal block rather than on a long set of test chamber leads.

Provisions for adding water to the bottom of the chamber for temperature quenching and assuring high humidity shall also be provided.

3.2 Pre-Operability Test Functional Verification

Prior to the performance of the operability test, the transmitter's accuracy shall be determined at 0, 350, 400 and 450 inches WC as a baseline of the system when installed in the chamber.

3.3 Operability Test

The transmitter loop will be powered in accordance with Figure 2 for the entire operability test period.

At the start of the test and during periods when output test are not being performed, the low pressure port shall be left at atmospheric pressure external to the test chamber, and the high pressure port shall be pressurized at 450 inches WC. The transmitter output and the pressure monitors output shall be recorded every 60 seconds during the period from the start of the test through the end of the first 10 minutes from achieving the peak profile temperature. For the remainder of the first hour, the values shall be recorded every 10 minutes. Thereafter, the values will be recorded every 15 minutes.

Once during the first 30 minutes, the output of the transmitter and the pressure monitor shall be recorded at 0, 350, 400, and 450 inches WC. This test shall be repeated at one hour elapsed time, and then at 3 hours elapsed time. During these functional tests, the periodic measurements may be foregone (That is, only the functional test result need be taken. Both periodic and functional tests need not be performed simultaneously.)

3.4 Tolerance

Tolerance on electrical voltage shall be ±2%. The chamber pressure will be ±10% of the specified values, unless otherwise indicated.

3.5 Equipment

All instrumentation, measuring and test equipment used in the performance of the test program shall be calibrated in accordance with Nutherm International, Inc. Quality Assurance Program. Standards used in performing all calibration shall be traceable to the National Institute of Standards and Technology (NIST). When no national standards exist, the basis for calibration shall be otherwise documented. The following equipment, or equivalent will be used to document the results of the test:

- HP 34401A Multimeter

- Daytronics System 10 Data Acquisition System

- Rochester DPG-600 Digital Pressure Gauge

- Well filtered Voltage source.

## 4.0 ENVIRONMENTAL CONDITIONS

The equipment will be subjected to an environmental exposure test within a chamber. Testing will be performed to the following requirements.

Environmental Profile[1]

| Period | Maximum | Temperature, °F Target | Minimum |
|---|---|---|---|
| Start | | Room Ambient | |
| 15 s.(Best Effort) | - | Ramp to 257 | - |
| 15 to 30 s (Best Effort) | - | Ramp to 285 | |
| 30 to 60 s | - | 285 | 285 |
| 60 to 75 s | - | Ramp to 224[2] | 224 |
| 75 s to 90 s | - | Ramp to 194[2] | 194 |
| 90 to 100 s | - | Ramp to 185[2] | 185 |
| 100 to 350 s | - | Ramp to 124[2] | 124 |
| 350 s to 3 hours | 130 | 124 | 120 |

Note 1: Saturated steam will be used as the heat source. This method will maintain 100% relative humidity at atmospheric pressure. Humidity monitoring is not required.

Note 2: Ramp from 285 to 124 degrees must envelop minimum temperatures. A longer ramp time is acceptable if necessary to assure enveloping.

Note 3: This profile includes 15 °F margin from 15 seconds through 100 seconds in accordance with IEEE-Std. 323-1974 and -1983. Only one transient is being performed because the peak and duration of the transient will not present a significant thermal shock to the components and there is adequate margin through the use of the 15°F margin and the use of saturated steam.

Periods below the specified minimum environmental and loading parameters shall not be considered as part of the required test period.

## 5.0 POST-TEST INSPECTION

Any physical damage or change in appearance that occurred during the operability test shall be recorded as a test observation or deviation as appropriate.

## 6.0 ACCEPTANCE CRITERION

The test specimens shall remain functional during the test period. The test results, which may include temperature recordings, sketches of electrical circuitry setup, data sheets, test observation sheets, and instrumentation descriptions, shall be provided to the responsible engineer for evaluation. The measured pressure from the Rosemount transmitter shall be within ±2.5% of the Rochester pressure gauge measurement (0.4 MA or 12" WC) [Ref. 1].

## 7.0 QUALITY ASSURANCE

Quality Assurance shall be performed in accordance with Nutherm Quality Assurance Manual QA-N-10179-5, Rev. 5. This program conforms to ANSI N45.2 (1977), NQA-1 (1989), and 10CFR50, Appendix B.

Quality Control inspections, if imposed during this test, shall be in accordance with "Design Basis Event (DBE) and Operability Test Inspection Procedure" Number QCI-10.2.22, Rev. 1.

## 8.0 REFERENCES

ComEd Nuclear Design Information Transmittal, NDIT No SEC-DR-97-055, Requirement for Testing of Rosemount Transmitter for HELB Profile without Conduit Seals, 2/6/97.

FL:DBE14

FIGURE 1

Layout of Equipment for Rosemount Transmitter Operability Test

Junction Box with 3, ¼ " weep holes in bottom and 9, 1 inch openings for conduit in bottom with conduit fittings and 3, 1 inch openings in top with conduit fittings and 3 inch conduit stubs. The top of the stubs must be at least 2 inches from the top of the chamber.

Box size: 1 to 2' long
8 to 12" high
6 to 10" deep.

Box to have cover, but does not need a tight seal.

Transmitter leads to exit from box from conduit directly above the flexible conduit from the transmitter.

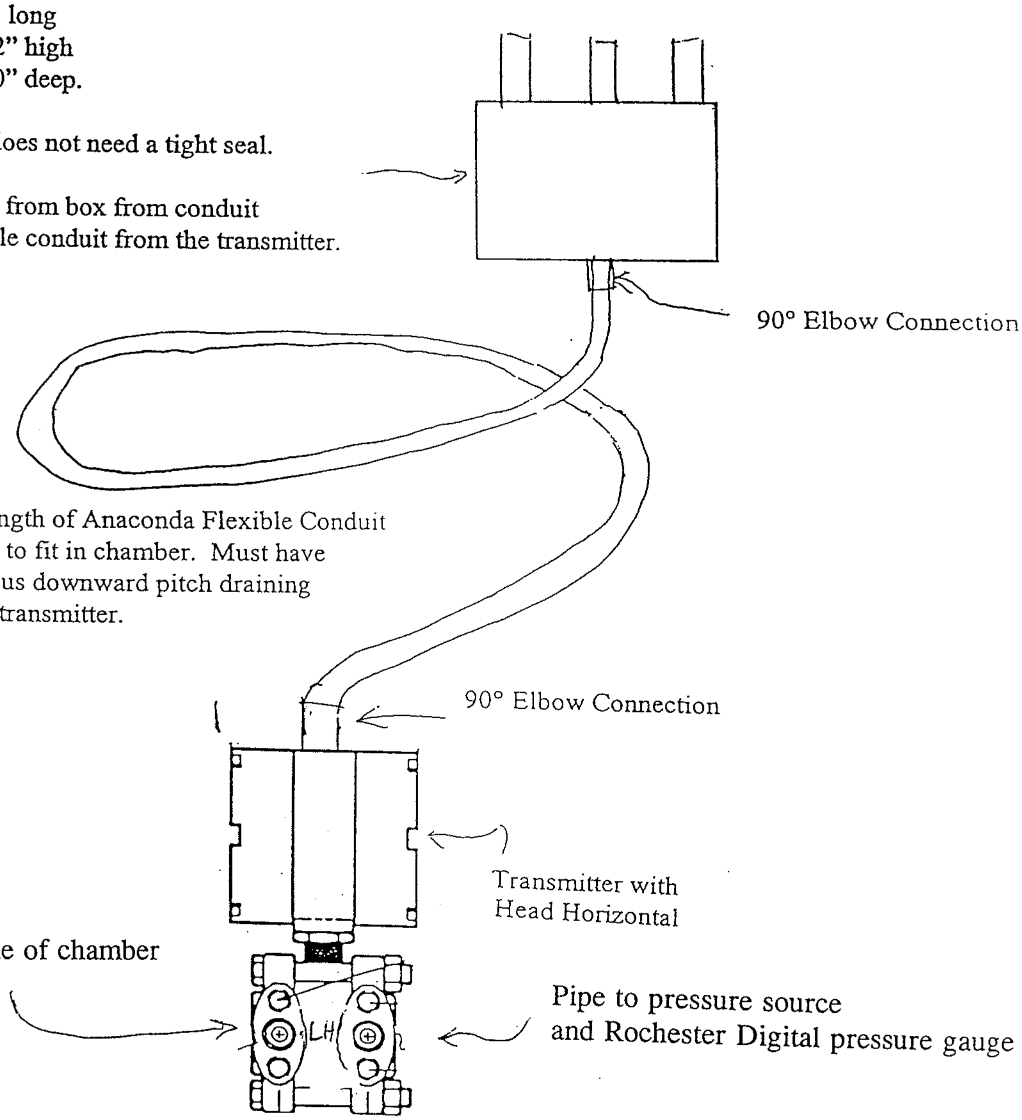
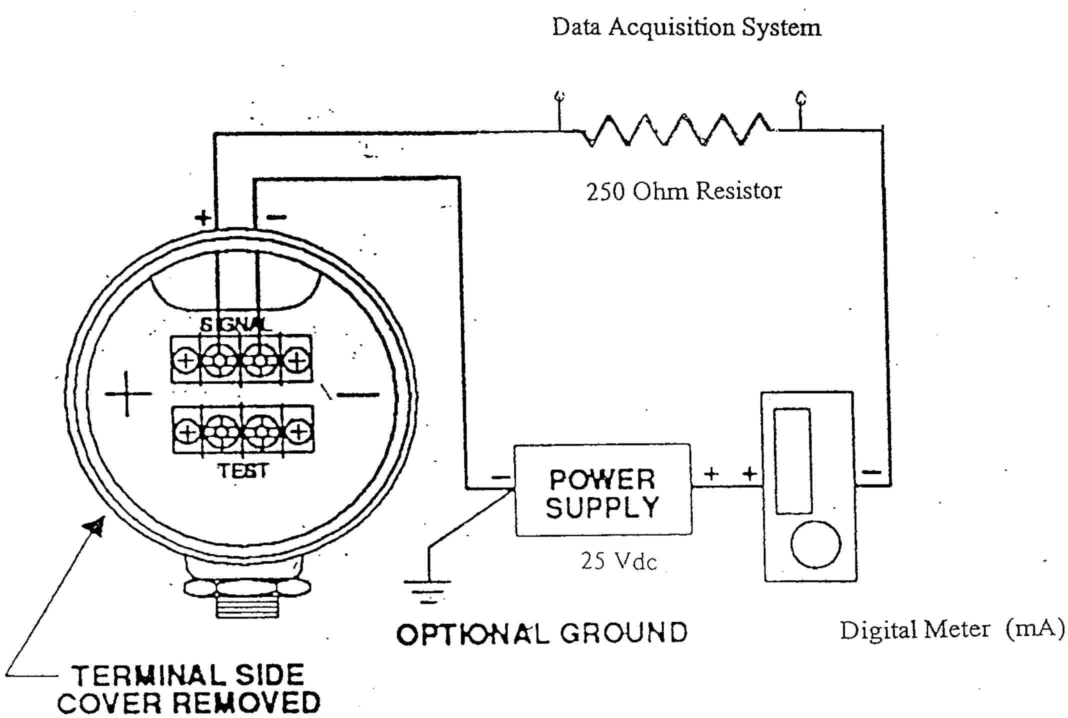


FIGURE 2

Test Circuit Electrical Layout




Note: Chamber Thermocouple shall be connected to the data acquisition system. The thermocouple shall be located approximately 2 inches from head of test specimen.

# ATTACHMENT II

## TEST RESULTS DATA SHEETS
## D-175P

TEST RECORD COPY

| Nutherm INTERNATIONAL, INC. Mt Vernon, IL 62864 (618) 244-6000 | DATA SHEET DBE / DBA | No.: D-175 P | Rev. No.: 0 | Page: 1-4 |
|---|---|---|---|---|

## TEST RECORD

Specimen NTL No(s.): 6127

Job No(s.): CWE-7832

Start Date and Time: Feb 20 '97 09:00 Finish Date and Time: Feb 20 '97 12:07

Chamber Temperature Recording Thermocouple NITC No.: 06 Channel No. 7 Range: 0-400°F

NITC No.: ______ Channel No. ______ Range: ______

NITC No.: ______ Channel No. ______ Range: ______

Ambient Temperature Recording Thermocouple NITC No.: 098 Channel No. 1 Range: 0-400°F

Humidity Channel No.: N/A Pressure Channel No.: 15

Recording Speed: Variable Chart No.: N/A

## Calibrated Test Equipment

| Description | Calibration Due Date | NI # | Function/Range(s) |
|---|---|---|---|
| Daytronic Data Acquis | 3-13-97 | 445 | Ch. 1, 7, 15, 17, 18, 998 |
| R.I.S. Digital gauge | 1-30-98 | 389 | INPUT inches W.C. |
| Hewlett Packard | 3-7-97 | 466 | OUTPUT mADC |
| Timer | 8-20-97 | 450 | Time |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Notice of Anomaly ______

Tested by: Danelle Parrish [signature] Date: 2-20-97

Reviewer's Signature ______ Date ______

Approval Signature: [signature] Date: 2/21/97

FL:244

58095-13-1

| Nutherm INTERNATIONAL, INC. | Data Sheet DBE/DBA | No.: D-175 P | Rev. No.: 0 | Page: 2-4 |
|---|---|---|---|---|
| | | Test Observations | | |

1.) Pictures were taken prior to test Start.
2.) Verified no leaks in tubing.
3.) Function tested pressure switch in chamber prior to test start.

| Inches W.C. | mADC |
|---|---|
| 0. | 4.0106 |
| 349.7 | 15.205 |
| 400.6 | 16.833 |
| 450.9 | 18.455 |

4.) Test Starts 09:00

| Time | output mADC | input inches W.C. | output VDC across resistor | |
|---|---|---|---|---|
| 0. | 18.873 | 473.9 | with Steam injected initially set at 450" w.c. | |
| 1. min | 18.464 | 443.4 | 4.674 | 09:01 hrs. |
| 2. | 18.415 | 443.5 | 4.602 | |
| 3 | 18.275 | 442.8 | 4.577 | |
| 4 | 18.192 | 442.3 | 4.543 | |
| 5 | 18.203 | 442.0 | 4.555 | |
| 6 | 18.203 | 441.1 | 4.548 | |
| 7 | 18.200 | 440.9 | 4.548 | |
| 8 | 18.177 | 439.9 | 4.548 | |
| 9 | 18.195 | 439.9 | 4.540 | |
| 10 | 18.191 | 439.2 | 4.548 | |
| 20. min | 18.117 | 436.0 | 4.528 | |
| | 4.2067 | 0. | cycle 1 | |
| | 15.348 | 350.1 | | |
| | 16.952 | 400.9 | | |
| | 18.522 | 450.4 | | |
| 30. min | 18.524 | 450.0 | | |
| 40. | 18.514 | 450.2 | | |
| 50. | 18.464 | 449.6 | | |
| 60. | 18.434 | 448.2 | | |
| 65:05 | 18.471 | 448.1 | cycle 2 | |
| | 4.1574 | 0.3 | | |
| | 15.373 | 351.6 | | |
| | 16.936 | 400.3 | | |
| | 18.508 | 449.6 | | |

Notice Of Anomaly

Tested By: Donald Damish (signature)  Date: 2-20-97

FL:244

58086-13-1

| Nutherm INTERNATIONAL, INC. | Data Sheet DBE/DBA | No.: D-175 P | Rev. No.: 0 | Page: 3-4 |
|---|---|---|---|---|
| | | Test Observations | | |

4.) continued

| Time | output mADC | input inches W.C | | | |
|---|---|---|---|---|---|
| 70. min | 18585 | 451.8 | | | |
| 75. | 18.496 | 449.2 | | | |
| 90. | 18.546 | 450.7 | | | |
| 105. min | 18.515 | 449.8 | | | |
| 120. | 18.497 | 449.3 | | | |
| 135. | 18.474 | 448.7 | | | |
| 150. | 18.535 | 450.9 | | | |
| 165. | 18.521 | 450.5 | | | |
| 180. | 18.516 | 450.7 | 12:00 | Hrs. | |
| | 4.1424 | 0.8 | cycle | 3 | 12:02 |
| | 15.318 | 350.8 | | | |
| | 16.902 | 400.2 | | | |
| | 18.511 | 450.6 | | | |
| | Test | End | 12:07 | | |

5.) Post Test Inspection: No visible damage noted. Switch had moisture on outer shell when chamber opened. No moisture noted inside either cover of switch after test.

Notice Of Anomaly

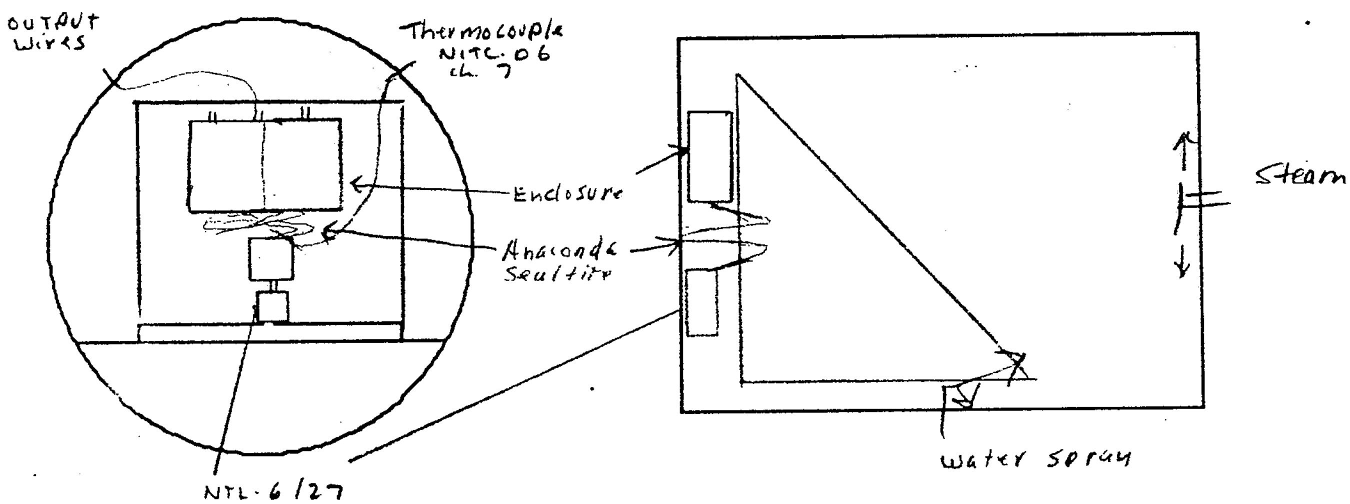
Tested By: James Parrish  Date: 2-20-97

FL:244  58086-13-1

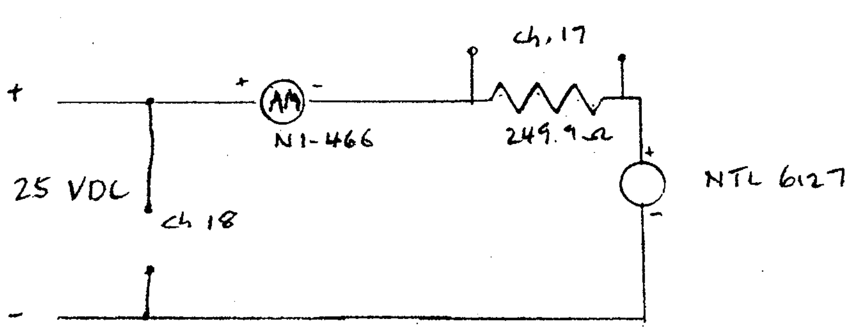
| Nutherm INTERNATIONAL, INC. | **Data Sheet** DBE/DBA | D-175P | Rev 0 | Page 4-4 |
|---|---|---|---|---|
| | | Test Observations (C) | | |

chamber

View | Side View




Electrical Schematic




Notice Of Anomaly

Tested By: Darrell Parrish | Date: 2-20-97

# ATTACHMENT III

# CHAMBER TEMPERATURE DATA

Attachment 3. Chamber Temperature Versus Required

| Time (Seconds) | Actual Temperature (°F) | Required Temperature (°F) |
|---|---|---|
| 0 | 69.3 | 68.9 |
| 5 | 114.1 | 68.9 |
| 10 | 160.0 | 68.9 |
| 15 | 152.6 | 68.9 |
| 20 | 151.5 | 68.9 |
| 25 | 161.6 | 68.9 |
| 30 | 170.6 | 68.9 |
| 35 | 184.5 | 68.9 |
| 40 | 198.1 | 68.9 |
| 45 | 210.9 | 68.9 |
| 50 | 221.6 | 68.9 |
| 55 | 232.2 | 68.9 |
| 60 | 242.5 | 68.9 |
| 65 | 250.3 | 68.9 |
| 70 | 257.9 | 68.9 |
| 75 | 263.8 | 68.9 |
| 80 | 268.7 | 68.9 |
| 85 | 272.7 | 132.0 |
| 90 | 276.5 | 195.0 |
| 95 | 279.7 | 257.0 |
| 100 | 281.2 | 266.0 |
| 105 | 282.6 | 276.0 |
| 110 | 285.8 | 285.0 |
| 115 | 286.2 | 285.0 |
| 120 | 286.7 | 285.0 |
| 125 | 287.8 | 285.0 |
| 130 | 289.1 | 285.0 |
| 135 | 288.0 | 285.0 |
| 140 | 286.6 | 285.0 |
| 145 | 285.3 | 265.0 |
| 150 | 283.9 | 244.0 |
| 155 | 284.9 | 224.0 |
| 160 | 284.2 | 214.0 |
| 165 | 287.8 | 204.0 |
| 170 | 285.5 | 194.0 |
| 175 | 284.8 | 190.0 |
| 180 | 286.4 | 185.0 |
| 185 | 285.3 | 182.8 |
| 190 | 280.8 | 181.6 |
| 195 | 274.8 | 180.4 |
| 200 | 274.1 | 179.2 |
| 205 | 273.9 | 178.0 |
| 210 | 271.6 | 176.8 |
| 215 | 269.1 | 175.6 |
| 220 | 266.5 | 174.4 |
| 225 | 262.9 | 173.2 |
| 230 | 259.1 | 172.0 |
| 235 | 252.6 | 170.8 |
| 240 | 244.7 | 169.6 |
| 245 | 240.0 | 168.4 |
| 250 | 234.9 | 167.2 |
| 255 | 231.1 | 166.0 |
| 260 | 227.2 | 164.8 |
| 265 | 224.6 | 163.6 |
| 270 | 222.1 | 162.4 |
| 275 | 220.8 | 161.2 |
| 280 | 219.8 | 160.0 |
| 285 | 224.8 | 158.8 |
| 290 | 227.0 | 157.6 |
| 350 | 227.9 | 143.2 |
| 410 | 230.9 | 128.8 |
| 470 | 233.3 | 124.0 |
| 530 | 214.2 | 120.0 |

Attachment 3. Chamber Temperature Versus Required

| Time (hours) | Actual Temperature (°F) | Required Temperature (°F) |
|---|---|---|
| 0.16 | 210.4 | 120.0 |
| 0.18 | 204.8 | 120.0 |
| 0.20 | 197.7 | 120.0 |
| 0.21 | 193.2 | 120.0 |
| 0.23 | 192.3 | 120.0 |
| 0.25 | 190.0 | 120.0 |
| 0.26 | 176.0 | 120.0 |
| 0.28 | 164.1 | 120.0 |
| 0.30 | 149.9 | 120.0 |
| 0.31 | 149.9 | 120.0 |
| 0.33 | 144.6 | 120.0 |
| 0.35 | 128.6 | 120.0 |
| 0.43 | 128.0 | 120.0 |
| 0.51 | 125.5 | 120.0 |
| 0.60 | 126.6 | 120.0 |
| 0.68 | 145.0 | 120.0 |
| 0.76 | 124.8 | 120.0 |
| 0.85 | 124.6 | 120.0 |
| 0.93 | 126.2 | 120.0 |
| 1.01 | 125.1 | 120.0 |
| 1.10 | 127.1 | 120.0 |
| 1.18 | 126.0 | 120.0 |
| 1.26 | 129.1 | 120.0 |
| 1.35 | 127.1 | 120.0 |
| 1.43 | 126.2 | 120.0 |
| 1.51 | 125.7 | 120.0 |
| 1.60 | 124.6 | 120.0 |
| 1.68 | 123.5 | 120.0 |
| 1.76 | 122.6 | 120.0 |
| 1.85 | 125.3 | 120.0 |
| 1.93 | 124.2 | 120.0 |
| 2.01 | 124.8 | 120.0 |
| 2.10 | 123.3 | 120.0 |
| 2.18 | 123.3 | 120.0 |
| 2.26 | 123.3 | 120.0 |
| 2.35 | 123.5 | 120.0 |
| 2.43 | 123.7 | 120.0 |
| 2.51 | 124.2 | 120.0 |
| 2.60 | 124.0 | 120.0 |
| 2.68 | 124.0 | 120.0 |
| 2.76 | 123.5 | 120.0 |
| 2.85 | 124.8 | 120.0 |
| 2.93 | 124.2 | 120.0 |
| 3.01 | 123.3 | 120.0 |
| 3.10 | 123.7 | 120.0 |
| 3.18 | 125.1 | 120.0 |
| 3.26 | 123.3 | 120.0 |
| 3.35 | 123.3 | 120.0 |
| 3.43 | 90.5 | 70.0 |

# C DESIGN BASIS ENVIRONMENTS

## C.1 Environmental Requirements for RISC-3 Applications

10CFR50.69(d)(2) requires that there be reasonable confidence that RISC-3 components be capable of performing their safety-related function under design basis conditions throughout their service life. Accordingly, **design basis** normal and accident conditions should be used as the basis of RISC-3 accident function assessments. Many of the environments used in EQ activities under 10CFR50.49 are **licensing** basis requirements or supplemental design information rather than design basis requirements. The licensing basis requirements, such as an enveloping inside-containment profile, are more conservative than need be considered for a RISC-3 accident function assessment and need not be used as the basis for an accident function assessment. The following subsections describe the differences between design and non-design basis information. Formal guidance on what constitutes design basis information is contained in NEI 97-04, Appendix B (November 2000)[14] [7].

## C.2 Accident Profiles Appropriate to RISC-3 Applications

As a starting point for EQ under 10CRF50.49, most plants use enveloping accident temperature and pressure profiles that contain a significant margin. This profile is not the design basis profile but rather a combined profile that envelops multiple design basis profiles (for example, a spectrum of main steam line breaks [MSLBs] and loss-of-coolant accidents [LOCAs]). The enveloping profile is used for convenience and ease of licensing.

Figures C-1 and C-2 show a typical containment profile enveloping the possible accident conditions and an actual design basis accident (DBA) LOCA profile. The margin between the actual profile (which is part of the design basis) and the enveloping profile is also shown. Figure C-1, with its logarithmic scale, seems to indicate that there are no significant margin differences between the two curves. However, when the curves are plotted on a linear scale, as shown in Figure C-2, very large margins are obvious. At approximately 2.5 hours, large margins become apparent in the linear representations. The margins are in excess of 102°F (57°C) from 1 hour and 55 minutes through the end of the plot at 11 hours and 15 minutes. The early portion of the

[14] NEI 97-04, Appendix B (November 2000) is contained in Revision 1 to NEI 97-04, which is dated February 2001.

excess margin peaks at 170°F (94°C). These margins are in excess of any margin that may have been applied to meet EQ requirements. Accordingly, the EQ special treatment that applies to and is appropriate for RISC-1 components includes large degrees of purposeful and hidden margins. These large degrees of margin are not necessary for RISC-3 applications that have low safety significance.

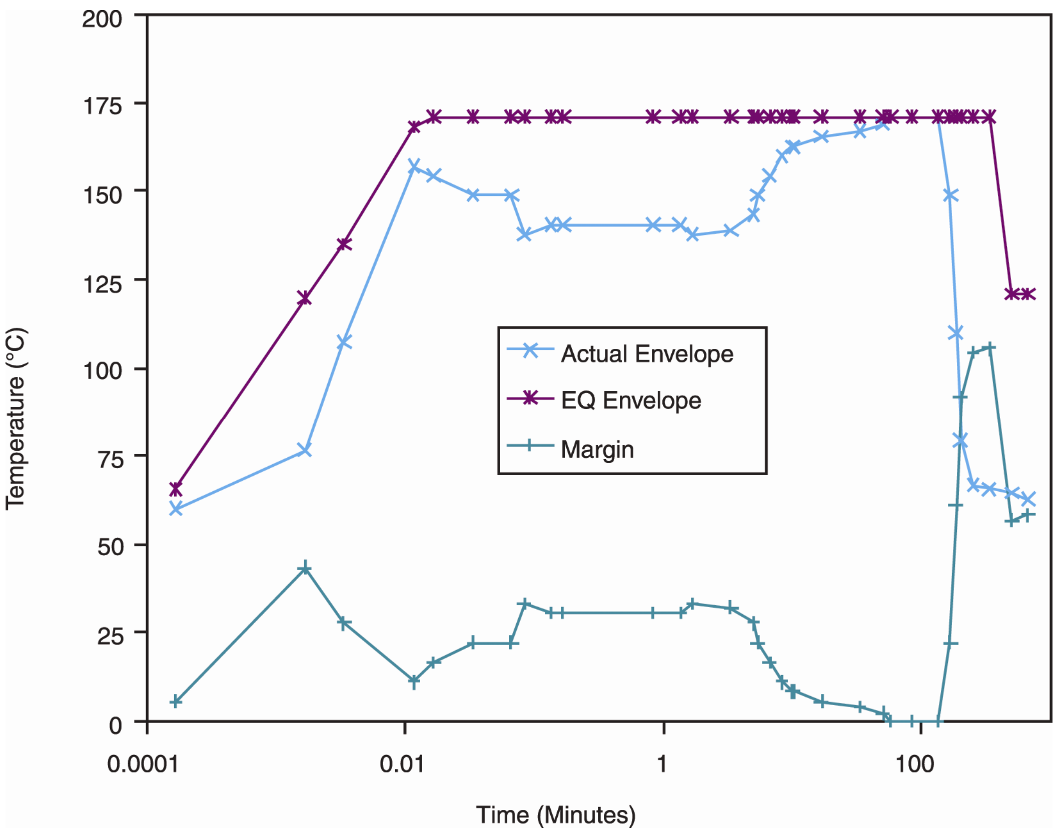



**Figure C-1**
**Typical Margins in Inside-Containment Environmental Requirement Enveloping Profile (Logarithmic Scale)**

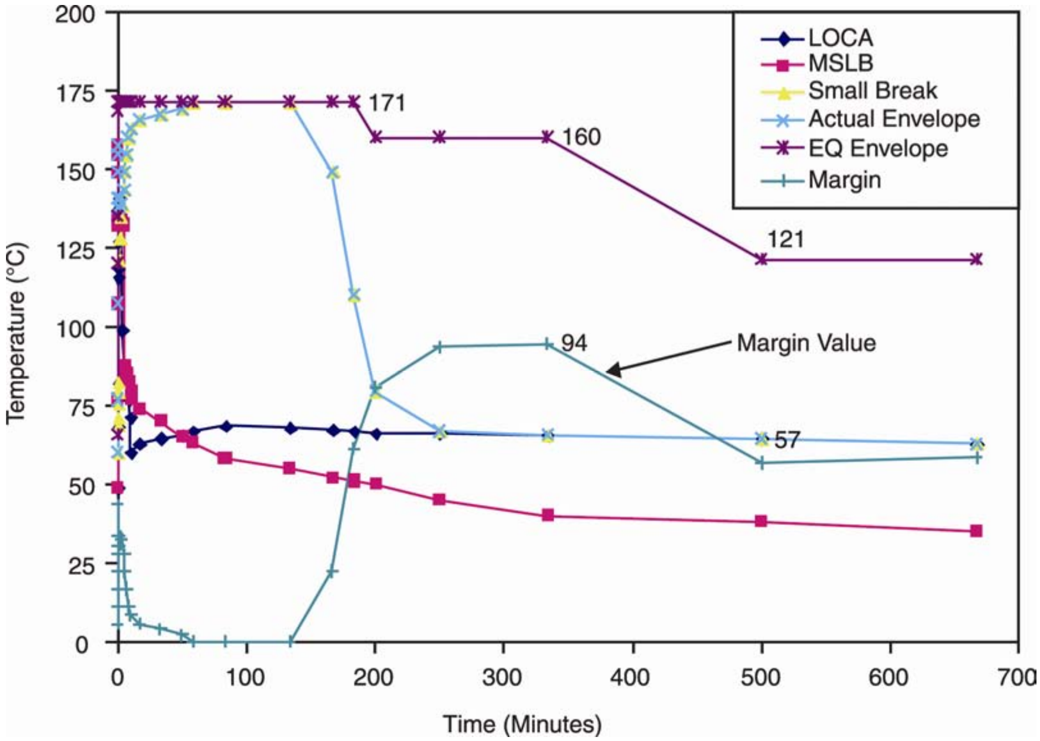



**Figure C-2**
**Typical Margins in Inside-Containment Environmental Requirement Enveloping Profile (Linear Scale)**

To establish a reasonable confidence in the performance of accident function, a required curve that closely follows the actual envelope (for example, a 180-minute peak of 340°F [171°C] followed by a ramp to 163°F [73°C]) is sufficient for analysis or test purposes for RISC-3. Similar results occur for high-energy line break (HELB) profiles. If multiple accidents apply to a RISC-3 component, each accident design profile should be assessed independently rather than in an additive or complementary manner. Assessing actual design basis profiles should allow a broader range of components to be acceptable for RISC-3 applications, and the level of effort required to make that determination is expected to be lower.

In addition to requiring inside-containment components to be qualified to an enveloping accident profile, plants may require the same profile for outside-containment components to allow the use of the component anywhere in the plant. For RISC-3 components located outside containment, there is no reason to use the LOCA profile for a component that is located outside containment and will experience a HELB or a temperature-/radiation-only event.

## C.3 Accident Duration and Required Operating Time

Accident duration commitments are normally licensing basis commitments. Under 10CFR50.49 qualification programs, numerous different durations exist in the industry, ranging from 30 days to 1 year, depending on whether the plant is licensed for hot or cold shutdown and the point at which the license was granted. For RISC-3 components, consideration of the period of need for

the component's function may allow the use of shorter periods in preparing accident function assessments (AFAs). Electrical equipment design functions that support or impact design basis functions credited in the licensee safety analyses or necessary to meet U.S. NRC requirements and associated operating times should be used as a basis for operating time assessments in an AFA. Operating times do not need to have margins added for use in RISC-3 AFAs.

With respect to establishing reasonable confidence in the performance of RISC-3 accident function, the most damaging portion of the post-accident condition is the first 5–25 hours, when temperature and pressure conditions are elevated. Thereafter, the accident profiles rapidly return to near-normal temperatures and pressures, as described in Section 6.4 of the EPRI report *Nuclear Power Plant Equipment Qualification Reference Manual* (TR-100516) [13]. The integrated radiation dose at the end of 10 days is approximately 75% of the total integrated dose at 100 days, assuming that significant core damage actually occurs during the accident. Accordingly, the early portion of an accident profile is the period that is most stressing to a component. If the component can withstand the severe conditions at the beginning of an accident and retain function, there is a high likelihood that it will continue to function through the less stressful remainder of the accident. Therefore, in assessing the ability of a RISC-3 component to withstand containment accident conditions, the focus should be on the effects of the front end of the accident profile where the conditions are most severe. Under 10CFR50.49, equipment operating time is typically demonstrated by the qualification test duration or supplemental analysis using the test conditions (for example, Arrhenius analysis of the test temperature profile). For the AFA, such methods are not required, and conclusions regarding long-term post-accident functionality can be based on engineering judgment.

## C.4 Other Accident Considerations

Secondary effects of an inside-containment accident, which affect components located outside containment, are much less severe than those in the inside-containment conditions. These effects result from heat transfer through the containment wall, heat and radiation transfer from circulating cooling water, and heat from large motors used to pump the fluids. Temperatures build more slowly over the course of a few days and then gradually trail off as the containment cools. The secondary effects have a much lower, broader peak. The integrated dose builds similarly to that of containment but to a much lower level. The assessment of secondary effects of inside-containment events generally will consider relatively low integrated radiation doses and/or moderate thermal exposures that are within the capability of most industrial components.

HELBs outside containment tend to have rapid transients with low peak pressures of approximately 1 psig. The pressure wave generally lasts less than 1 minute and dissipates rapidly when building blowout panels break free. Although peak temperatures are appreciable, the durations are generally short, and a return to near-normal temperatures occurs within a few hours. Some plants have a few HELBs and MSLBs that have relatively high temperatures (~300°F [~150°C]) that can last for a number of hours. Thereafter, return to normal ambient temperature is rapid. The energy content of such accident environments can be quite high and may represent one of the larger challenges to equipment. Assessment of these severe HELBs and MSLBs may be as difficult as assessment of inside-containment LOCAs. However, the bulk of outside-containment components are not subject to such HELBs. Accordingly, the consideration

of the lesser HELBs will generally entail assessment of a component's ability to withstand a short-term temperature spike and condensing moisture conditions. Simple sealing may be sufficient, and many electrical components are known to withstand condensing moisture if they are properly configured to prevent pooling of water at terminations. Electronic components will generally require sealing to prevent condensation from affecting circuit board operation.

## C.5 Normal Environment Bases

Normal environmental conditions are considered in 10CFR50.49 EQ programs in order to address aging effects. Although normal conditions used in EQ may be related to actual temperature measurements or may be based on HVAC equipment sizing calculations, neither set of data is **design basis** information. The HVAC equipment sizing calculations sized cooling equipment to maintain a worst-case temperature in a room, based on high outdoor temperature coupled with high cooling water temperatures and peak thermal load from operating equipment. Typical calculations are based on limiting temperatures to a maximum of 104–122°F (40–50°C) under adverse conditions. In most cases, this results in the HVAC equipment having excess capacity so that temperatures are much lower than the equipment sizing calculation basis. For RISC-3 applications, actual temperatures are most appropriate to use in considering whether normal temperature has any significant effect on accident function. Although the determination of actual temperatures for EQ purposes generally demands a rigorous monitoring of actual conditions, much less rigor is necessary for RISC-3 applications. Temperatures from operator logs may be scanned to identify peak and off-peak conditions. Assumptions made on the basis of personnel comfort could also be the basis (for example, personnel are comfortable in the area; therefore, the temperature is 85°F [30°C] or less).

The use of actual temperatures rather than design basis temperatures should lead to longer lives for components or allow the use of equipment that is appropriate to the condition but not necessarily as rugged as would be required to function under higher HVAC design calculation temperatures.

# D
# EVALUATION AND RELAXATION OF EQ REQUIREMENTS

## D.1 Qualified Life and RISC-3 Service Life

A qualified life has been established for virtually all components requiring qualification to 10CFR50.49. Nearly all qualified lives are based on thermal limitations of the organic materials of the components. A service life is necessary for a RISC-3 component only if the effects of normal service can significantly impact the likelihood of its performing its design basis function under accident conditions. If prolonged exposure to normal service conditions significantly degrades the ability of a RISC-3 device to function, periodic maintenance or a replacement schedule is necessary in order to provide reasonable confidence in the performance of accident function.

If a component's qualified life, as previously defined by the plant's 10CFR50.49 program, is long enough to cover or exceed the expected remaining plant operating life, efforts to establish a longer RISC-3 service life are unnecessary. However, if the qualified life is shorter than the expected life of the plant, the aging of the component should be assessed with regard to its importance to performing accident function. Although qualified life can be limited by radiation or mechanical cycling concerns, such limitations are rare, and the most limiting constraint is generally the thermal stress to organic materials. Additional thermal life may be justified based on a number of considerations, including the following:

- Focusing the life assessment on weak-link material rather than on all materials
- Establishing material service life using material capability data rather than accelerated aging limitations
- Determining temperature effects on service life using representative information rather than conservative EQ values (for example, using a more representative activation energy or actual temperatures rather than conservative ones)
- Extending service life based on operating experience with non-safety-related equipment or equipment used in other applications or industries
- Applying excess thermal margin from accident simulation
- Using in-service inspection and testing as the basis for continued use

Some components do not experience any significant aging from normal conditions. In general, such components should already have very long qualified lives assigned and probably will not need a life assessment. It may also be found that the aging from normal service is independent of

the accident exposure degradation. If such independence exists and normal exposures do not lead to a failure mode, assigning a life constraint is unnecessary.

The reassessment of life for RISC-3 components may not eliminate all replacements. Some devices experience degradation from normal service, especially if normal ambient temperatures are elevated. However, RISC-3 service life should be significantly longer than qualified lives and thereby provide relief from frequent replacements.

### *D.1.1 Life Assessment Based on Weak-Link Material*

EQ-qualified life determinations are generally based on a calculated life of a thermally weak-link material within the component based on an accelerated thermal aging exposure at an elevated temperature. *Weak-link* in this context describes the material with the shortest calculated life at the assumed operating temperature based on available EQ test results. Although conservative, this approach is unnecessarily restrictive if the weak-link material is not critical to functionality. For RISC-3 applications, eliminating materials not critical to accident functions from consideration[15] is appropriate when evaluating equipment service life.

#### D.1.1.1 Electrical Fail-Safe Functions

If the only required safety function for a RISC-3 application is that the device de-energize and remain in its associated de-energized state, life limitations for any of the electrical insulation within the device may be unnecessary. For example, if a solenoid-operated valve (SOV) has a de-energized safety function, the SOV coil, lead wire, wire splices, and electrical housing gaskets and seals need not be evaluated for service life limitations. The life would be based on any organic components that could interfere with a transfer to the de-energized state. The focus would shift to non-electrical organic subcomponents that could shrink, expand, or break as a result of accident stress coupled with aging effects. Such components could prevent a transfer to the de-energized state. Generally, these components are not part of the high-temperature SOV coil and are likely to be subjected to lower operating temperatures. Their assessment may lead to longer component lives.

Careful consideration of eliminating the coil and associated components from life should be given to applications that could affect operations if coil burnout occurs. In such cases, retaining a coil-based life would be appropriate.

#### D.1.1.2 Non-Critical Parts Based on Accident Conditions

Some subcomponents, particularly enclosure seals and gaskets, protect equipment internals from high-pressure steam effects during LOCA/HELB events. However, if functionality is required only for accidents not having high-pressure steam environments (for example, radiation- or

[15] It is appropriate to eliminate subcomponents not affecting function from the development of a qualified life under 10CFR50.49 as well.

temperature-only accident conditions), these parts need not be considered in an evaluation of equipment service life. The most obvious examples are electronic transmitter cover gaskets and O-rings.

### D.1.2 Use of Material Capability Data Rather Than Accelerated Aging Data

Large quantities of aging rate data based on the Arrhenius thermal aging model exist in industry databases.

The common form of the data is:

$$\ln t = B + \phi / kT \qquad \textbf{Eq. D-1}$$

Where:

t = Time (hours)

B = Constant

$\phi$ = Activation energy

k = Boltzmann's constant (0.8617E-4 eV/K)

T = Temperature (K) (°C + 273.15), including temperature rise

This form of the Arrhenius model is referred to as the *slope/intercept* form.

The model can be rearranged to:

$$t = e^{(B+\phi/kT)} \qquad \textbf{Eq. D-2}$$

Industry databases commonly provide data in the form of B and $\phi$/k for determining the time required to achieve a specific endpoint (for example, loss of a fixed percentage of elongation-at-break) in a material when it is held at a specific temperature. For example, B and $\phi$/k for glass-filled phenolic from an industry record are -16.922 and 11,651.8, respectively. Using the second formula, the life of glass-filled phenolic at 40°C is 6.4E8 hours or 7.3E4 years, indicating an exceedingly long life for this material at 40°C. For a glass-filled phenolic component with a 50°C temperature rise in a 40°C environment, the operating temperature would be 90°C, and the life would be reduced to 439 years.

The slope/intercept form of the model can be used to identify the total thermal capability of a material at a specific temperature. A second form of the model may be used to equate periods of time at two different temperatures:

$$t_1 = t_2 * \exp\left[\frac{\phi}{k}\left(\left(\frac{1}{T_1}\right)-\left(\frac{1}{T_2}\right)\right)\right] \qquad \textbf{Eq. D-3}$$

Where:

$t_1$ = Equivalent time at normal plant temperature (hours)

$t_2$ = Aging test time (hours)

$T_1$ = Normal plant temperature (K)

$T_2$ = Aging test temperature (K)

$\phi$ = Activation energy (eV)

k = Boltzmann's constant = 0.8617E-4 eV/K

This form of the model may be used to quantify the thermal effects of accident environments so that they can be compared to the total expected life as determined using the slope/intercept method. For example, for a hypothetical case in which an accident environment temperature of 100°C occurs for the first 24 hours and then immediately returns to 40°C, the effect of the exposure at 100 or 150°C for the temperature rise case can be equated to life consumed at 40°C. As in the slope/intercept version, $\phi$/k equals 11,651.8; however, the constant B is not needed in this equation. A period of 24 hours at 100°C equates to 9517 hours (~1.1 years) at 40°C. A period of 24 hours at 150°C equates to 2270 hours (~0.25 years) at 90°C. Given the very long lives identified with the slope/intercept calculation (7.3E4 years at 40°C and 439 years at 90°C), no significant degradation would be expected for the hardy glass-filled phenolic material from thermal stress caused by the combination of normal and accident environments. In these cases, the thermal capability far exceeds the rigors of the application, providing confidence that the material can withstand normal thermal conditions with no effect on accident function.

There are multiple databases associated with the EQ industry. These databases contain data for use of the Arrhenius model for thermal aging and also to provide radiation-withstand capability for materials. The thermal capability of materials may also be derived from such sources as the Underwriters Laboratory (UL) relative thermal index[16], which is the temperature that a material can successfully withstand for 100,000 hours. This time and temperature (thermal index) may be

[16]According to UL, the relative thermal index is the maximum service temperature for a material, where a class of critical property will not be unacceptably compromised through chemical thermal degradation, over the reasonable life of an electrical product.

equated to an in-service time and temperature using Equation D-3. Reasonable estimates of in-service time and temperature may also be achieved by using the 8°C or 10°C rules. UL thermal indices are available from http://data.ul.com/ULiQ_Link/index.asp. Section A.5.9 of the EPRI report *Radiation Data for Design and Qualification of Nuclear Plant Equipment* (NP-4172SP) provides a further discussion of UL thermal indices [12].

### D.1.3 Extension of Service Life Based on Operating Experience

Many RISC-3 applications outside containment will have relatively benign accident conditions. Many of these devices are used in non-safety-related applications under similar environments and service conditions (for example, continuously energized). Operating experience from the non-safety applications may be used to lengthen RISC-3 service life, especially for components with relatively benign accident conditions. For example, if a continuously energized EQ SOV with a given ambient temperature has a calculated qualified life of 5 years, and a population of similar continuously energized valves in the same ambient temperature has not experienced failure in 10 years, increasing the service life of the RISC-3 application beyond 5 years is appropriate. The assessment of the extension of service life must consider the degrading effects of the accident environment. For example, if the accident environment increased from 104 to 160°F (40 to 71°C) for a few days and then returned to normal, the effect on the life of the component would be minimal—and extension to 10 years would be appropriate. However, if the accident temperature was high for a significant period of time and high radiation doses were involved, the full extension of service life based on operating experience would not be recommended.

Inspection of equipment removed at the end of qualified life from either EQ or RISC-3 applications may also indicate that normal service is not causing significant degradation of components. Operating experience with non-safety components may provide the same insights. The lack of identifiable degradation may be used as a basis for extending RISC-3 service life by a reasonable factor such as 25–30%. If inspection of components removed after the extended life is implemented, and the components are found to be in “like-new” condition, further extension may be implemented. If the component is found to have experienced significant degradation, the life should be adjusted downward again. As previously noted, degradation resulting from the accident exposure should be considered when making such service life changes.

### D.1.4 Applying Excess Thermal Margin from Accident Simulation

The assessment of service life may consider the total thermal content of the EQ tests with respect to the severity of the normal service conditions and the accident conditions. Accident service and normal service cause degradation of the component. The expected degradation from the plant design basis accident service conditions may be significantly less than the degradation that occurred during the qualification test accident simulation. Under the EQ constraints, the use of **excess** thermal degradation from the accident simulation is not normally applied to extend the qualified life. However, under the less restrictive constraints of **reasonable confidence**, excess accident degradation capability may be used to provide confidence in additional service life.

The 10CFR50.49 qualifications are often based on manufacturers' EQ tests that bound, with margin, plant profiles that envelop all of the existing design basis profiles for the plant (for example, LOCA, MSLB, small-break LOCA, and HELBs). Accordingly, two separate areas may exist where excess withstand capacity exists for the device: 1) periods in which the test profile exceeds the need of the EQ profile and 2) periods in which the EQ profile exceeds the design basis profiles.

Analysis of the excess thermal content should allow extension of the service life of the RISC-3 component while reasonable confidence in the ability of the device to perform its accident function is retained. The use of the re-analysis results does not degrade the accident function; all of the surrounding considerations of the EQ program remain intact. The device has been proven to withstand the specified radiation, steam, and chemical environments. The only change being made is the evaluation of the thermal environment to determine if excess capability exists and whether it may be used for life consideration.

Appendix E provides examples of the assessment of the RISC-3 service life with respect to evaluation of the thermal content of the test exposure and consideration of the construction materials' total capability.

### *D.1.5 Use of In-Service Inspection and Testing as a Basis for Service Life*

In some cases, inspection and/or test activities may be an adequate basis for continuing service life. This is especially true for cases in which accident environments are not greatly in excess of normal conditions. Inspection of devices for signs of significant aging (for example, significant darkening or melting of coil components or stiffening of rubber or insulation materials) coupled with functional testing is a satisfactory basis for the continued use of a RISC-3 component that will not be exposed to an accident environment with a severe thermal, radiation, or steam condition. These inspections need not be performed on all RISC-3 components but may be performed on individual components that conservatively represent other RISC-3 applications. Additionally, insights on the same type of device in the same or a more severe service environment would be applicable regardless of whether the device was in RISC-3, RISC-1, or even RISC-4 service.

## D.2 Rigidity of RISC-3 Service Life

In many cases, the original qualified life or the reassessed RISC-3 service life will exceed the expected plant life. However, cases are expected where service stresses are high enough that normal service life must be limited in order to provide reasonable confidence in the performance of the accident functions of RISC-3 components.

Under 10CFR50.49, EQ equipment or parts must be replaced within the limits of the qualified life unless new evaluations establish a longer replacement interval. Under the constraints of **reasonable confidence** in the performance of accident function, this very conservative constraint need not be maintained for RISC-3 components. More liberal replacement windows may be used (for example, interval ±25%).

If in-service failures of RISC-3 components occur and the corrective action program failure analysis determines that aging was the cause, an appropriately shortened replacement interval or compensating maintenance activities must be implemented or actions must be taken to reduce the severity of the normal environment. When extending the life of a RISC-3 component, care must be taken to ensure that failure, if it occurs, is detectable either by natural change of state or by periodic testing. Inspection and testing are required by 10CFR50.69(d)(2) to the point of providing reasonable confidence in performance of design basis function; however, no requirements with respect to the type or periodicity of inspection and testing are stated.

## D.3 Mechanical Cycling Service Life Limits

In the vast majority of cases, EQ-required maintenance, refurbishment, and subcomponent replacement intervals will be driven by thermal life considerations. Examples include the replacement of subcomponents, such as seals, gaskets, and circuit cards. In a limited number of cases, maintenance, refurbishment, or subcomponent replacement intervals may be driven by wear cycles. Typically, the EQ wear cycle limit is based on the number of cycles replicated in the EQ program and not on the device's capabilities, based on other literature or experience.[17] In these cases, longer wear cycle limits can be established, based on discussions with the manufacturer or other available information (for example, catalogs) on the capabilities of equivalent commercial components. Frequently, the commercial catalog cycle limits are 100 or more times greater than the number of cycles simulated in the EQ test program. If evidence of a much higher cycle limit is identified, the cycle limit may be extended with reasonable confidence.

## D.4 Subcomponent Replacement and Component Repairs

Under the constraints of EQ, certain subcomponents' replacement and refurbishment actions were not permitted because such actions could not be linked through traceability or a rigorous assessment to the EQ basis. In some cases, component repairs (such as replacement of discrete components on a circuit board of a transmitter) either were not allowed or could be performed only by the manufacturer's repair facility. Under the less restrictive constraints of RISC-3 **reasonable confidence**, there is more latitude. Replacement components may be procured only as equivalent to the originals or assessed as being satisfactory for the performance of accident function. Traceability documentation for the components is not required from the manufacturer.

In addition, for cover seal O-rings, replacement each time the device cover is opened may be unnecessary. If the seal is a non-crush application (that is, the seal is formed by partial compression rather than by compression to the point of crushing), the O-ring could be given a visual-tactile inspection for damage and hardening and reused if found acceptable. The use of this practice could be left to the instrumentation and control technicians based on their experience with non-safety transmitters of the same type. If no damage has been observed in the

[17] The cycles simulated in EQ test programs were often limited due to both cost and schedule considerations or were based on assumptions regarding the maximum number of cycles anticipated in typical nuclear power plant safety-related applications with an expectation of a 40-year life and limited in-service testing.

seals for those transmitters, there is basis to eliminate replacement of used but serviceable cover seal O-rings. On the practical side, if likelihood of damage to the gasket exists, taking an inexpensive O-ring to the work location is much less expensive than interrupting the work to go to the warehouse for an O-ring if the original is found to be damaged.

Instrument and component repairs that are allowed on non-safety components should also be allowed on RISC-3 components. If like replacement parts and staff skills exist to repair components, repairs that can be made cost effectively should be undertaken. Post-repair functional tests should be included to verify that the repaired device functions as intended. If different replacement parts are used, their similarity to the original part should be evaluated either in an equivalency evaluation or under the associated AFA.

# E
# EXAMPLES OF RELAXING EQ REQUIREMENTS

## E.1 Service Life Assessments

Section 6 and Appendix D describe various ways in which the service life of a RISC-3 device can be extended. This section provides examples of those methods.

### *E.1.1 Life Assessment Based on Functionally Critical Materials*

Some qualified lives have been determined based on the aging of the worst-case, most age-sensitive material without regard to the function of the material within the component. In addition, some subcomponents are important to function in certain applications and not in others. To determine if a material is important to function, a failure modes and effects analysis (FMEA) would be performed for the most limiting materials (that is, those with the lowest activation energies). The FMEA should take into consideration the constraints or lack thereof of the RISC-3 application.

For example, assume that a limit switch had neoprene screw grommets for the housing cover plate that are important to the environmental seal for steam accident conditions. Neoprene has an activation energy of 0.9 eV. The next most limiting material, a phenolic, has an activation energy of 1.1 eV. If the neoprene grommets are not important to function, the life will increase by a large factor (often five or more, depending on the service and accelerated aging temperatures). For containment applications, the gaskets on the screws are necessary for the accident environment seal against a LOCA or MSLB. For HELB areas, the screw gaskets are less critical. A review of the housing seal may show that they are not necessary for a transient, 1-psig or less event. The gaskets are definitely not needed for a temperature-/radiation-only application. Therefore, for temperature-/radiation-only applications, the service life could be extended by a significant factor. The change in life may be calculated using Equation D-2 or D-3. For HELB areas, a review of the seal system or removal of the grommet so that the screws clamped the lid directly could be used to determine that the grommets are unnecessary and would not be life limiting, allowing the use to be extended as well. For containment LOCA/HELB applications, the screw gaskets are necessary, and the life would not be extendable by this means.

## E.2 Use of Material Capability Data Rather Than Accelerated Aging Data

The qualified life of most components is generally based on the extrapolation of a period of accelerated aging at an elevated temperature. The practical and commercial constraints on the accelerated aging may have limited the temperature and duration of accelerated aging in the qualification program. If the aging temperature must be relatively low (for example, 121°C) to protect a subcomponent, the duration of the aging period required to attain a long qualified life would require extremely long oven exposures that would be costly. Therefore, some components may not have been significantly aged in an accelerated aging exposure. Accordingly, the identification of the slope and intercept information for the Arrhenius plot for the critical component and the calculation of life at the operating temperature will indicate whether a significant portion of the thermal life was consumed in the EQ process.

Two methods are readily available for use: slope/intercept Arrhenius data (see Equation D-2) and UL thermal index data for use with the Arrhenius comparison model (see Equation D-3). For example, assume that Nylon 6/6 was the limiting material and thermal aging was performed for 168 hours at 121°C. If the service temperature is 50°C and the activation energy is 0.84 eV, using Equation D-3, the equivalent thermal life is 4.4 years, as follows:

$$t_1 = t_2 * \exp\left[\frac{\phi}{k}\left(\left(\frac{1}{T_1}\right) - \left(\frac{1}{T_2}\right)\right)\right] \qquad \textbf{Eq. E-1}$$

Where:

$t_1$ = Equivalent time at normal plant temperature (hours)

$t_2$ = Aging test time (hours), 168 hours

$T_1$ = Normal plant temperature (K), (273.15 + 50°C)

$T_2$ = Aging test temperature (K), (273.15 + 121°C)

$\Phi$ = Activation energy (eV), 0.84 eV

$k$ = Boltzmann's constant = 8.617E-5 eV/K

From existing industry databases (for example, Equipment Qualification Databank), the slope and intercept are 9765 and -17.37, respectively. Using Equation D-2, the resulting expected mechanical life for the component is more than 389,000 hours, or approximately 43 years at 50°C, as follows:

$$t = e^{(B + \phi / kT)}$$ **Eq. E-2**

Where:

t = Life in hours

B = Constant (intercept), -17.37

$\phi$ = Activation energy, 0.84 eV

k = Boltzmann's constant (0.8617E-4 eV/K)

$\phi$/k = 9765 K

T = Temperature (K) (°C + 273.15) = (50 + 273.15) = 323.15 K

The slope/intercept calculation indicates that the life of this nylon can be significantly greater than the 4.4 years simulated in the test unless the thermal and/or radiation degradation from the accident consumes the difference. A HELB lasting less than 1 hour that raises the temperature of the device to no more than 121°C and returns to normal in 12 hours can be shown by inspection to have a limited effect. By very conservatively assuming that the entire 12-hour period causes the device to be at 121°C, the equivalent life consumed at 50°C can be calculated using Equation E-1. The result is that 12 hours at 121°C equals 2750 hours at 50°C or 0.3 years. Accordingly, this accident would consume very little of the 43-year expected life for the material. Therefore, for a RISC-3 application, the thermal life of the component could be increased by a factor of nearly 10 from 4.4 years to 42 years.

A query of the UL Thermal Indices Databank (see Appendix D.1) indicates that Nylon 6/6 has a thermal index of 140°C for mechanical strength. Using Equation E-1 and the 0.84-eV activation energy, 100,000 hours at 140°C equates to 7.1E7 hours (8150 years) before failure at 50°C, which further indicates a much longer life than the limited accelerated exposure of 168 hours at 121°C.

## E.3 Identification and Use of Excess Accident Function Capability

Figure E-1 shows a test thermal profile and a design basis profile that have been converted to time step curves rather than smooth curves. There is a significant difference in thermal content between the two curves, with the test profile having a much larger thermal content.

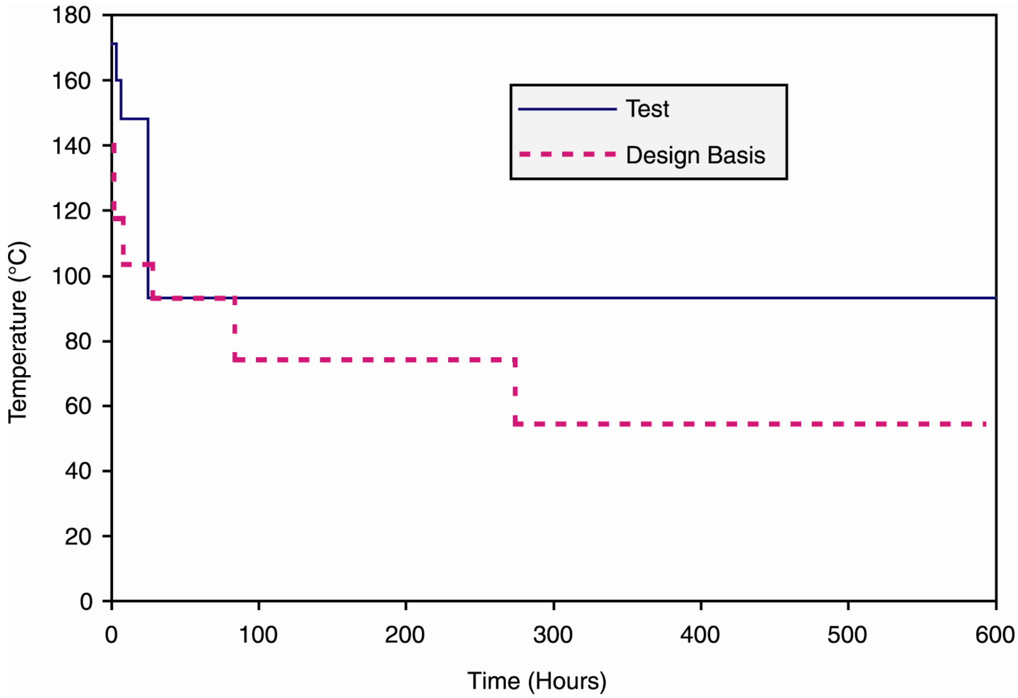



**Figure E-1**
**Comparison of a Test Thermal Profile to a Design Basis Profile**

Table E-1 shows the time step durations and temperatures for the test profile. For this example, the weak-link material is assumed to have an activation energy of 1.1 eV, which is in the range of expected activation energies for the materials used in nuclear applications. Using Equation E-1, a 50°C (323 K) comparison base temperature has been chosen. Column 5 contains the equivalent duration of the temperature for each time step. Table E-2 contains the time step data for the design basis profile. The summation of the equivalent durations for the test profile equals 462,000 hours (52.7 years). The summation of the equivalent durations for the design basis profile is 27,100 hours (3.1 years). The excess thermal capacity of the test profile is 434,900 hours (49.6 years) at 50°C. The design basis profile has an actual duration of 34.5 days that has been accounted for in the analysis. A portion of the excess should be used to ensure accident function for conservatism. If 150% of the design basis equivalency (1.5 * 3.1 or 4.7 years) were retained for reasonable confidence in accident function, 48 years of time may be converted to service life. The 48 years of additional life would then be added to the qualified life from the EQ file to establish the total service life available for the RISC-3 component. If the device already had a qualified life of 30 years, 18 years of excess capability would be available for accident function beyond that already allocated for reasonable confidence in accident function.

**Table E-1**
**Test Profile Equivalency to 50°C (323 K) Assuming a 1.1-eV Activation Energy**

| Step | Duration (hours) | Temp (°C) | Temp (K) | Equivalent Duration (1.1 eV, 50°C) |
|---|---|---|---|---|
| 1 | 3 | 171 | 444 | 142,790 |
| 2 | 3 | 160 | 433 | 68,784 |
| 3 | 18 | 148 | 421 | 178,111 |
| 4 | 696 | 93 | 366 | 72,301 |
| | Total equivalency (hours) | | | 461,986 |

**Table E-2**
**Design Basis Profile Equivalency to 50°C (323 K) Assuming a 1.1-eV Activation Energy**

| Step | Duration (hours) | Temp (°C) | Temp (K) | Equivalent Duration (1.1 eV, 50°C) |
|---|---|---|---|---|
| 1 | 0.83 | 140 | 413 | 4,565 |
| 2 | 7.5 | 118 | 391 | 7,246 |
| 3 | 20 | 104 | 377 | 5,748 |
| 4 | 55 | 93 | 366 | 5,713 |
| 5 | 190 | 74 | 347 | 2,923 |
| 6 | 555 | 54 | 327 | 900 |
| | Total equivalency (hours) | | | 27,096 |

The analysis does not need to use 50°C as the equivalency temperature. The normal temperature of the RISC-3 application would be the most appropriate temperature to use so that the result would provide an immediate indication of the degree of service life improvement that is possible.

All comparisons of an EQ test profile to a design basis profile will have some excess thermal content. Not all comparisons will have an excess thermal capability as large as 48 years at 50°C. Some will be smaller; some may be larger. However, the excess thermal content will cause nearly all service lives for RISC-3 applications to be significantly larger than the associated qualified lives had been.

## E.4 Cyclic Life Limitations for a Motor-Operator Valve

The EQ tests for motor-operated valve (MOV) operators have simulated 2000 cycles for a qualified life limit. IEEE Std 382 required a minimum of 500 full-stroke operations during qualification under rated load [16]. This cycling was intended to “wear age” the electrical components (that is, the motor, torque switch, and limit switch) in the operator. The rated load was applied in order to stress the motor and cause the torque switch to operate. The application of 2000 full-load strokes did not cause the casing and gear system to be significantly fatigued, and the overall operator is capable of more than 2000 strokes at full load. Bulletin 89-10 programs for these valves have evaluated and maintained these actuators to date [17]. Options exist for extending the cycling of MOVs applied within their load rating. The first would be the inspection of contacts and rotors on the limit switches. If there were no significant wear, continued use would be acceptable. The torque switch contacts and body could be similarly assessed. Continued use of the motor could be based on functional tests with current and temperature monitoring, winding insulation resistance, and polarization index. Such evaluations could be performed at 2000 cycles and then at 250- to 500-cycle intervals beyond 2000 cycles. A second option would be a one-time replacement of the electrical components so that the components of concern from an environmental point of view would no longer be of concern.

One key limit to continued motor operator use must be considered. After the requirements of Bulletin 89-10 were implemented, loads were increased on some MOVs to ensure proper function of the valves. Accordingly, some motor operators operate at loads in excess of rated load. For these actuators, casing fatigue limits must be considered for operations in excess of 2000 cycles. This is not an EQ or RISC-3 limitation but rather an actual fragility limit of the housing related to the degree of overload normally encountered.

# F
# RELAXATION OF EQ MAINTENANCE, CALIBRATION, REFURBISHMENT, AND MAINTENANCE ACTIVITIES FOR RISC-3 COMPONENTS

As described in Appendix D, environmental qualification (EQ) files contain requirements for actions that preserve the EQ of a component. These requirements may include that periodic maintenance or calibration be performed or that seals be replaced any time a device cavity is opened. The following subsections give examples of the types of EQ requirements that exist for various components and describe their relevance to RISC-3 accident function.

## F.1 Electronic Device: Transmitter

Pressure transmitters have electronic components and termination cavities that must remain dry to allow accident function. For inside-containment applications, the housing and electrical port must be sealed against high pressure (for example, 35–50 psig). Also, the electronics must be suitable to withstand elevated temperatures and significant gamma radiation doses. (The housings are sufficient to significantly reduce the effects of beta radiation to the electronics.)

### *F.1.1 Installation Requirements*

Unused conduit hubs as well as used conduit hubs must be sealed. A high-pressure electrical entrance seal is necessary for inside-containment applications.

Outside containment, a high-pressure electrical entrance seal is not needed for low-pressure, transient steam conditions, but conduits should drain away from transmitter housing. See *Operability Test Report—Rosemount Model No. 1153db5pa Pressure Transmitter*, which is presented in Appendix B [15].

### *F.1.2 Configuration Requirements*

For an EQ application, the qualification requires that the cover gaskets be replaced if the electronics or termination cavity is opened. For RISC-3 inside-containment applications, the cover gaskets may be inspected and reused if they are resilient and undamaged. Alternately, the cover gaskets may be replaced with commercial materials having the same configuration and material properties. For inside-containment applications, an electrical entry pressure seal capable of withstanding containment accident pressure is necessary for the termination cavity. The unused hub must be sealed with a thread sealant and suitable National Pipe Thread (NPT) plug.

Outside containment, cover gaskets may be inspected and reused if they are resilient and undamaged. Replacement with commercial materials is acceptable. No conduit seal is necessary, and conduits should drain from the transmitter.

### F.1.3 Maintenance Requirements

Beyond replacement of electronic boards at the end of service life and periodic calibration, there are no maintenance requirements for transmitters.

### F.1.4 Service Life Limits and Subcomponents

The service life for the RISC-3 transmitters should be re-evaluated in accordance with the examples in Sections E.1 through E.3. Alternately, experience with calibration may be used to support their continued use. If the records for the RISC-3 transmitters and related non-safety transmitters show continued stability of calibration (for example, the devices remain within calibration range and are not exhibiting severe drift), the devices may continue to be used. The reassessment of service life according to Sections E.1 through E.3 should provide significant extensions of service life of seals and electronics boards used in the transmitters. Periodic calibration in accordance with standard plant procedures will support reasonable confidence in accident function and identify any significant deterioration during normal periods of operation.

### F.1.5 Calibration Requirements

Some transmitter qualifications require specific periods for calibration to cover artifacts related to accelerated thermal and radiation aging. The high temperatures and dose rates used in accelerated aging caused significant calibration shifts. These conditions do not occur under normal conditions. Accordingly, the calibration periodicities required for EQ should not be applied to RISC-3 devices. Rather, the standard plant calibration intervals applicable to mild environment and non-safety devices should be applied.

## F.2 Electrical Device: Solenoid-Operated Valve

All solenoid-operated valves (SOVs) move either the main valve seat or a pilot seat through the operation of a solenoid armature that compresses a spring when the coil is energized. In the piloted version, the main seat is moved by the force of the pressure from the air or hydraulic source when the pilot valve directs the flow to the appropriate side of the diaphragm or operating piston.

Some SOVs also contain limit switches that indicate whether the valve is in the de-energized or energized position. The switches generally operate through a magnet on an extension of the armature. The magnets cause reed switches to change position.

The key concern beyond direct thermal and radiation damage is to keep electrical subcomponents from being wetted as the result of steam exposure. Some manufacturers such as ASCO want the coil cavity to drain, while others such as Valcor and Target Rock want the cavity to stay completely dry. The following subsections identify the actions that are necessary to provide reasonable confidence in accident function and to preclude significant numbers of in-service failures.

### *F.2.1 Installation Requirements*

The manufacturer provides installation instructions. Many of these instructions are related to proper practices for installing the valve and should be followed, but they are not direct requirements for withstanding the operating environment. Examples include the inspection and preparation of weld connections for process lines and following welding instructions. However, sealing the electrical conduit threaded connection and placing a conduit seal can be an environmental withstand requirement, depending on the application. If the electrical housing must be sealed to support pressurized steam from a LOCA or MSLB and the device could experience a steam event, a seal suitable for high-pressure steam (that is, 35–50 psig) must be installed. However, if the application at worst case has a postulated transient low-pressure steam environment (such as a HELB), the use of appropriate conduit installation procedures can eliminate the need for a high-pressure conduit seal. If the conduit is installed such that condensing moisture drains away from the electrical housing of the SOV, no seal is needed for transient HELB steam conditions. If the conduit drains toward the SOV, a seal is desirable. For transient steam conditions outside containment, an epoxy or RTV seal would be satisfactory in place of a LOCA-qualified seal. The following is a summary for seals required by the manufacturer:

- If a seal is exposed to a LOCA or MSLB inside containment and function is required for either event, install a seal satisfactory for high-pressure conditions.
- If a seal is exposed to a transient, low-pressure steam event and function is required for the event, install conduits such that they drain away from the electrical housing. Or, if this cannot be done, install a low-pressure seal (for example, an RTV or epoxy). A high-pressure seal may be installed at the utility’s option.

If there is no steam exposure (for example, elevated temperature or radiation only), no seal is necessary. Conduits should drain away from the device as a good practice.

Note: Some SOV manufacturers do not require a fully sealed configuration for high-pressure conditions. For example, ASCO requires a **sealed-drained** system. In this system, the conduit connection is sealed to the electrical housing but does not have a conduit seal at the electrical housing. Rather, the conduit must drain away from the SOV to allow water that may enter the housing through its base to drain away from the coil. This seal system expects some water entry but allows it to drain away such that the coil does not sit in water during operation. This type of seal should be maintained for inside-containment applications.

### F.2.2 Configuration Requirements

The configuration requirements for an SOV are generally the same as the installation requirements. If the seal to the electrical housing conduit or the electrical housing is opened, the seal must be restored. For inside-containment applications, if the electrical conduit seal is disturbed, it must be restored to its fully sealed condition. The resealing will depend on the nature of the seal in use and its as-found condition. However, inspection of the seal system may be used rather than arbitrarily replacing the seal system. If no damage has occurred from disassembly and reassembly is possible (for example, using an appropriate thread sealant restores the seal), reuse is satisfactory. If assembly and disassembly effectively damages seal components, the seals must be replaced for any device whose function depends on sealing under steam environments, whether inside or outside containment.

With respect to opening the electrical housing cover, the seal must be restored. However, if the seal gasket or grommet is inspected and found to be resilient and undamaged, it may be reused.

Alternately, a commercial grade seal or gasket with the same physical and chemical properties may be substituted for the **EQ-traceable** version of the gasket or seal. Given the lower cost of the commercial item, the replacement of the seal with a new seal at each opening of the device could be maintained. Arbitrary replacement with a commercial O-ring or gasket at each opening may be cost effective because checking gaskets and seals in and out of the warehouse carries a significant cost. A review of experience of the craft with the condition of seals during work may indicate the best practice; for example, if seal gaskets and grommets are always found in good condition, inspection would be useful. If seals are sometimes found deteriorated or damaged, arbitrary replacement at each opening of the device with commercial seal materials would be cost effective.

### F.2.3 Maintenance Requirements

There are no specific maintenance requirements for most solenoid-operated valves.

### F.2.4 Service Life Limits of Solenoid-Operated Valves and Subcomponents

The service life of an SOV and its subcomponents is driven by the service conditions of the application. For air system SOVs, no temperature rise occurs from the process. However, ambient temperature conditions may be elevated, depending on the proximity to piping system components for high-temperature process lines. The state of energization directly affects the temperature rise of the coil and therefore the surrounding organic materials. The temperature rise coupled with the ambient temperature will determine if a service life limitation is desirable. If ambient temperatures are low (<120°F [<50°C]) and the SOV is de-energized, service life is not a limitation for industrial SOVs. The materials of construction have very long lives at lower ambient temperature conditions when the SOV is normally de-energized.

However, continuous energization coupled with elevated normal environment conditions can lead to service-life-limiting conditions. For example, the qualified lives for energized ASCO

NP-8320 valve range from 11.6 years at 43°C (110°F) to as little as 2 years at 65°C (150°F). As described in the first part of this section, excess accident-withstand capability may be used to support the service life of the solenoid-operated valves. In addition, actual service temperatures may be as low as 30°C (85°F) year round. The 13°C (23°F) difference from 43°C (109°F) with a 30°C (86°F) ambient temperature causes the life of the coil to be over 40 years at 30°C (86°F) with the coil energized. Additional confidence in longer coil lives for ASCO valves may be derived from the EPRI report *Baseline Data Program for Environmental Qualification Condition Monitoring—ASCO Solenoid Operated Valves* (TR-107356), which describes a program to develop condition-monitoring data for ASCO SOVs [18]. Of the 54 valves in the program, 37 coils came from used valves that had been removed from service at the end of their qualified lives. In the research program, the valves were energized and subjected to thermal aging equivalent to their aging in the ASCO qualification program. Essentially, these coils were subjected to aging equivalent to twice their qualified life. Not 1 of the 37 coils failed during the test program, even though the valves were continuously energized during the oven aging at temperatures between 121 and 161°C (250 and 322°F).

### *F.2.5 Solenoid-Operated Valve Calibration Requirements*

There are no calibration requirements for SOVs.

## F.3 Electrical Device: Discrete Limit Switch

The discrete limit switch is an independent switch that is mounted external to a valve or damper to monitor its position (for example, fully open or fully closed). This section does not specifically cover limit switches that are internal to components because many different types of internal limit switches exist.

### *F.3.1 Installation Requirements*

For inside-containment applications that are required to function under pressurized steam environments, the sealing of limit switch housing is required to withstand pressures up to 50 psig. The operating shaft, electrical housing, and conduit entry must be sealed to keep moisture from entering the switch under accident conditions and causing shorting. Outside-containment sealing is much less critical. If conduits drain away from the limit switches, no significant moisture should enter the housing for low-pressure transient steam events.

### *F.3.2 Configuration Requirements*

The cover gaskets, screw seals, and shaft seals are required to maintain function during a LOCA/HELB-type event for inside-containment applications. An electrical conduit seal is likewise necessary.

For outside-containment conditions, low-pressure transient steam conditions, or dry conditions, a seal is not necessary if the conduits drain away from the limit switch housing. If this is not possible, an RTV or epoxy seal may be used in place of a high-pressure seal, that is, LOCA qualified.

If the limit switch is opened, the condition of seal materials including body gaskets and cover screw grommets should be inspected, and they should be replaced if damaged. If the operating shaft is removed from the mechanism, the shaft seals should be inspected before reassembly and replaced if damaged. Commercial grade equivalent seals may be used. Cover screws must be torqued to the manufacturer’s specification for inside-containment applications.

If the threaded conduit seal is removed, the threads must be cleaned and a thread sealant used when the seal is reassembled.

### *F.3.3 Maintenance Requirements*

There are no specific maintenance requirements for most limit switches.

### *F.3.4 Service Life Limits and Subcomponents*

Most limit switches do not have components that require periodic replacement. Switches similar to NAMCO types EA-170 or EA-180 will have long service lives at general area temperatures. Below 100°F (38°C), qualified lives exceed 60 years and exponentially decay to two years at very high temperatures (for example, 176°F [80°C] in the vicinity of some main steam isolation valve [MSIV] applications). Additional service life may be identified by conversion of excess thermal capability from accident simulations, which could lead to a doubling of the service life. At very high temperatures, the seal components will tend to deteriorate, and the organic operating mechanism components may lose structural strength.

### *F.3.5 Calibration Requirements*

There are no calibration requirements for the limit switch itself. Confirmation of correct interface between the limit switch arm and the device being monitored is part of normal installation and periodic surveillance of the plant. It is not a requirement of accident function bases.

# G CONSIDERATIONS FOR ACCIDENT FUNCTION ASSESSMENTS AND EQUIVALENCY EVALUATIONS

Section 2.6 describes the need for accident function assessments for RISC-3 applications that previously required 10CFR50.49 EQ. No technical equivalency evaluation is necessary when the replacement item is identical to the original device. If differences exist in the subcomponents, an equivalency evaluation is performed to resolve those differences that could affect accident function. If a different component is used as a replacement, an accident function assessment is necessary. This appendix provides listings of differences that could affect RISC-3 component accident function as well as guidance for their resolution.

Each example describes the differences in subcomponents that could affect accident function. The examples describe a range of important differences that could occur. Not all of these differences are expected to be relevant to a given equivalency evaluation or accident function assessment. The identification of numerous differences may be an indication that the new device should be considered as an alternate device, necessitating a design change rather than an equivalent change. This section identifies differences that could affect accident function from environmental and service conditions. Other differences may affect seismic capability or other important design issues, and these are beyond the scope of this report. Table G-1 summarizes the scope of items described in the examples.

**Table G-1**
**Summary of Components Illustrating Equivalency Evaluation Considerations**

| Section Number | Component |
|---|---|
| G.1 | Electromechanical device examples |
| G.1.1 | Solenoid-operated valve |
| G.1.2 | Limit switches |
| G.1.3 | Induction motors (small) for outside-containment use |
| G.1.4 | Relays and contactors (outside-containment applications) |
| G.2 | Electronic devices |
| G.2.1 | Pressure transmitters |
| G.2.2 | Power supplies (outside containment) |
| G.3 | Passive electrical devices |

**Table G-1 (cont.)**
**Summary of Components Illustrating Equivalency Evaluation Considerations**

| Section Number | Component |
|---|---|
| G.3.1 | Temperature elements (resistance temperature detector [RTD]) and thermocouples |
| G.4 | Connecting devices |
| G.4.1 | Terminal blocks (outside containment) |
| G.4.2 | Splice coverings (outside containment) |

## G.1 Electromechanical Device Examples

### *G.1.1 Solenoid-Operated Valve*

The following parts of a solenoid-operated valve (SOV) (see Tables G-2 through G-8) affected by an accident environment could directly cause failure, or their deterioration could allow the environment to affect other components:

- Coil
- Electrical housing (that is, the housing itself that forms the pressure boundary with the ambient environment)
- Seals for the electrical housing cover and entry port
- Body O-rings
- Dynamic seals
- Organic seats

Not all valves have each of these parts.

**Coil**

The insulation, potting compound, and bobbin used in the construction of an SOV coil can have different temperature ratings. The design of the coil (including the number of turns and the magnetic circuit configuration) affects the temperature rise that occurs during energization. Nuclear applications frequently require the continuous energization of SOV coils to allow fail-safe operation upon loss of power. Continuous energization causes a temperature rise within the coil and all adjacent components in the SOV. Deterioration of materials from long-term exposure to elevated temperatures is the concern. Materials may shrink and crack or eventually soften and flow. Cracking of the magnet wire insulation can cause a shorting of coil turns that would lead to coil burnout, especially if the coil is exposed to a moist environment.

**Table G-2**
**Attributes of Coil That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Coil temperature rise (as stated by the manufacturer or determined by test). | Should be less than or equal to original. | If temperature rise is significantly greater than original, coil life and life of surrounding organic components may be significantly affected. | If the coil is normally non-energized and accident energization is short (hours), a higher temperature rise should not be an issue. If the coil is normally energized, the effects on the coil and surrounding components must be addressed. A coil with a higher rated insulation system may be acceptable for higher temperature rise. However, O-rings and seats within the valve may age significantly more quickly. |
| Coil insulation and support material. | a. Device located in area with 100 krads to 1 Mrd total integrated dose (TID).<br><br>b. Device subject to >1 Mrd. | | a. Verify that Teflon has not been used as an insulation or support component.<br><br>b. Perform an analysis of material capabilities or radiation test. |
| National Electrical Manufacturers Association (NEMA) insulation class. | Should be equal to or higher than original (ratings from low to high: A, B, F, H, RH). | If coil is normally de-energized (energized less than 20% of the time), it may be acceptable. Coil life will be shorter if coil is continuously energized. | Verify that the coil rating is equal to or higher than original. If normally de-energized, lower rating is acceptable if the energized accident use period at elevated temperature is short. |
| Diode bridge (if applicable) must be rated for peak accident temperature. | Diode bridge allows an ac coil to be energized with dc power (not used in all dc SOVs). | Diode bridge may not be capable of functioning in high temperatures. | Verify that the diode bridge temperature envelops the peak temperature, including operating temperature rise, or perform an operability test at elevated temperature. |

**Table G-3**
**Attributes of Electrical Housing (Pressure Boundary with Ambient Environment) That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| If sealed, housing must have sufficient strength to withstand accident pressure without collapsing as indicated by the thickness and type of material of construction. | a. Used outside containment<br><br>b. Used inside containment | a. Housing should provide suitable physical protection for coil and other electrical components.<br><br>b. If sealed, housing must be able to withstand accident pressure. | a. NEMA 1 through 4 are acceptable.<br><br>b. Housing should have a pressure rating equal to or higher than that of the original housing. |

**Table G-4**
**Attributes of Electrical Housing Cover Seals That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| If housing is sealed, seal must exhibit proper hardness and resilience. | Used outside containment | The seal should be adequate to keep out dirt and condensation. | The seal should be adequate to support NEMA-4 pressure withstand. Silicone rubber and EPR are generally acceptable as seal gaskets or O-rings. |

**Table G-5**
**Attributes of Electrical Port Seals (If Required) That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| If housing is sealed, seal must exhibit proper hardness and resilience. | a. Used outside containment (HELB areas) | a. Option 1: Thread sealant on conduit connection and conduit draining from device adequate.<br>Option 2: Thread sealant on conduit connection and RTV or epoxy seal on conduit if it is the top entry to the device. | a. For HELB areas, electrical conduit should drain away from device. If not, moisture seal at or near electrical entrance to SOV (for example, epoxy or RTV) is required. |
| | b. Used in radiation-/temperature-only areas | b. Seal not required. | b. No action is needed. |
| | c. Used inside containment | c. If required to complete seal, full LOCA-proof seal needed. | c. Full pressure barrier seal on port is necessary if temporary wetting of coil is not allowed. Consult the manufacturer to determine if temporary coil wetting is allowed. Seal is definitely needed if a limit switch or terminal block is located in housing. |

### Body O-Rings

Body O-rings seal different pressure cavities within an SOV from one another and help retain process medium pressure within the SOV. Results of qualification research indicate that such seals will harden under severe duty but will retain their ability to provide pressure boundary [19, 20].

**Table G-6**
**Attributes of Body O-Rings That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Body O-rings must exhibit proper hardness and resilience. | O-ring must exert sufficient force against confining surfaces to complete seal. | Initial hardness must be correct; material must remain resilient and not be subject to excessive compression set with time in service. | Verify that original hardness is within range of original. Compare the radiation and thermal degradation characteristics (that is, hardening and set with exposure). |
| Dimensions, configuration, and cross-sectional shape. | O-ring must have the proper shape for the space confining it. | | Confirm that the dimensions of the new seal are appropriate for the cavity. Replacement O-rings should be made of the same material and have the same configuration as the original. |

## Dynamic Seals

Some SOV types have dynamic O-rings on the moving armature extension such that the dynamic O-ring seals against the wall of the SOV cavity and the armature extension. The degradation of the O-ring could lead to failure from blow-by or from sticking of the armature.

**Table G-7**
**Attributes of Dynamic Seals That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Material must be compatible with process medium. | In air systems, material must be compatible with water or oil if present. | EPR not satisfactory in oil; Viton is better, but it is not good for high radiation. | Confirm that the material is satisfactory for process medium and contaminants that have been experienced. |
| Material must have equal or better thermal and radiation characteristics. | Material may harden, soften, or swell with aging, which could affect function. | Material should be suitable for temperature, radiation, process pressure, and medium. | Compare radiation and thermal degradation characteristics within the process medium (for example, air or water); valve life may need to be limited or in-service testing may need to be performed to verify continued function. |
| Seal must exhibit proper hardness and resilience. | | | Compare durometry data. |

## Organic Seats

Some SOVs use EPR, Viton, urethane, or other rubber or plastic as a seat that meshes with a metallic port. Different materials have different abilities to withstand the rigors of service conditions.

**Table G-8**
**Attributes of Organic Seats That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Material must be compatible with process medium. | In air systems, the material must be compatible with water or oil if present. | EPR is not satisfactory in oil; Viton is better, but it is not good for high radiation. | Confirm that the material is satisfactory for process medium and contaminants that have been experienced. |
| Material must have equal or better thermal and radiation characteristics. | Material may harden or soften with aging. Seats that are too soft or too hard will not function properly. | | Compare radiation and thermal degradation characteristics. |
| Seat must exhibit proper hardness and resilience. | | | Compare durometry data. |

### *G.1.2 Limit Switches*

This section (Tables G-9 through G-14) pertains to discrete limit switches that are separate components rather than subcomponents of another device. For inside-containment switches, the housing and its seals must be able to withstand accident pressure. The operating mechanism's organic components must be able to withstand the peak temperature and radiation dose of the accident. A limited number of limit switch applications entail very high normal temperatures. The operating mechanism's organic materials must be able to endure the normal temperatures of such applications without losing strength. Greases used to lubricate the mechanism must not lose their lubricity or harden significantly as the result of elevated temperature and radiation doses.

Note: These examples apply to lever-operated and pushbutton-type limit switches. Other types of limit switches, such as magnetic proximity types, are not covered in these examples.

**Table G-9**
**Attributes of Electrical Housing (Pressure Boundary) That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| If sealed, housing must have sufficient strength to withstand accident pressure without collapsing as indicated by the thickness and type of material of construction. | a. Used outside containment<br><br>b. Used inside containment | a. Housing should provide suitable physical protection for coil and other electrical components.<br><br>b. If sealed, housing must be able to withstand accident pressure. | a. NEMA 1 through 4 are acceptable.<br><br>b. Housing should have pressure rating equal to or higher than that of the original housing. |

**Table G-10**
**Attributes of Electrical Housing Cover Seals That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| If housing is sealed, seal must exhibit proper hardness and resilience. | Used outside containment | The seal should be adequate to keep out dirt and condensation. | The seal should be adequate to support NEMA housing pressure withstand. Silicone rubber and EPR are generally acceptable as seal gaskets or O-rings. |

**Table G-11**
**Attributes of Electrical Port Seals (If Required) That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| If housing is sealed, seal must exhibit proper hardness and resilience. | a. Used outside containment (HELB areas) | a. Option 1: Thread sealant on conduit connection and conduit draining from device is adequate.<br>Option 2: Thread sealant on conduit connection and RTV or epoxy seal on conduit if it is the top entry to device. | a. For HELB areas, electrical conduit should drain away from device. If not, moisture seal at or near electrical entrance to SOV (for example, epoxy or RTV) is required. |
| | b. Used in radiation-/temperature-only areas | b. Seal is not required. | b. No action is needed. |
| | c. Used inside containment | c. If required to complete seal, full LOCA-proof seal is needed. | c. Full pressure barrier seal on port is necessary if temporary wetting of coil is not allowed. Consult the manufacturer to determine if temporary coil wetting is allowed. Seal is definitely needed if limit switch or terminal block is located in housing. |

**Table G-12**
**Attributes of Operating Shaft Dynamic Seals (Used on Lever-Operated Limit Switches) That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Material must have thermal and radiation characteristics equal to or better than those of the original. | Material may harden, soften, or swell with aging, which could affect function. | Material should be suitable for temperature and radiation conditions. | Compare radiation and thermal degradation characteristics; under very adverse normal conditions (for example, MSIV duty), life of limit switch may have to be limited or in-service testing may have to be performed to verify continued function. |
| Seal must exhibit proper hardness and resilience. | | | Compare durometry data. |

**Table G-13**
**Attributes of Operating Mechanism Organic Components That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Hardness, flexural strength, and/or tensile strength must equal or exceed original. | Depending on function of subcomponent, item may be in tension, compression, or flexure. For most organic materials used in operating mechanisms, these properties will be correlated to each other. | Mechanical properties of organic materials used in limit switches will degrade before electrical properties become a concern. | Verify that mechanical property of interest is acceptable.<br><br>Verify that material is acceptable for radiation dose.<br><br>Verify that thermal aging properties are equivalent to or better than the original.<br><br>Note: For applications with very high temperatures (>140°F), service life limitations may be necessary. |

**Table G-14**
**Attributes of Operation Pushbutton Boot Seal (Used on Pushbutton-Operated Limit Switches) That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Material must have thermal and radiation characteristics that are equal to or better than those of the original. | Material should provide moisture seal for high-humidity but low-pressure conditions and not harden to the point of impeding operation. | This type of switch is generally not suited for inside-containment applications due to pressure limitations of housing and materials of construction of switch mechanism. | |
| | | a. HELB area use: Seal is useful in preventing ingress of water subsequent to HELB. | a. Determine temperature/radiation characteristic from manufacturer under which material remains flexible, assess material capability, or perform radiation or temperature operability test. |
| | | b. Radiation-/thermal-only event. | b. Accident radiation and thermal conditions not likely to affect boot seal material. |

### *G.1.3 Induction Motors (Small) for Outside-Containment Use*

Small standard motors (less than 50 hp) may be exposed to HELBs or temperature-/radiation-only accident effects outside containment (see Tables G-15 through G-19). In general, most motors will not experience significant problems as long as condensing moisture does not wet lead connections to windings and terminations. Elevated temperature for short durations should not cause immediate failure.

**Table G-15**
**Attributes of Lead Insulation That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Temperature rating of lead insulation | Insulation should not thermally age significantly such that cracking could occur under normal or accident service. | Common lead materials are EPDM, EPR, silicone rubber, and Teflon. Polyetherether-ketone (PEEK) may also be used. | a. If motor is normally de-energized, the temperature rating of lead insulation is of limited importance.<br>b. If motor is normally energized, the temperature rating of the material should be equal to or higher than that of the original. |
| Material should exhibit the same resistance to radiation exposure | Insulation should not age significantly from irradiation such that cracking could occur under normal or accident service. | Common lead materials are EPDM, EPR, silicone rubber, and Teflon. PEEK may also be used | a. Below 100 krads, all common materials are acceptable.<br>b. Above 100 krads, exclude Teflon for use. All other materials acceptable for outside-containment radiation levels. |

**Table G-16**
**Attributes of Motor Housing That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Enclosure type should be equal to or better for exclusion of environment | Housings exist that are drip proof, slash proof, guarded, weather protected, totally enclosed, explosion proof, and dust-ignition proof. | | For temperature-/radiation-only environments, enclosures do not have to be sealed.<br>For HELB areas, the housing should provide sealing protection at least as good as the housing being replaced. |

**Table G-17**
**Attributes of Motor Winding That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Coil temperature rise (as stated by manufacturer or determined by test) | Should be less than or equal to that of the original. | If temperature rise is significantly greater, coil life may be significantly affected. | If motor is normally de-energized and accident energization is short (hours), higher temperature rise should not be an issue. If the coil is normally energized, effects of temperature rise on motor winding must be addressed (for example, higher temperature rise and a high-class insulation system may be acceptable). |
| Coil insulation and support material | a. Device located in area with 100 krads to 1 Mrd TID.<br>b. Device subject to >1 Mrd. | | a. Verify that Teflon has not been used as insulation or support component.<br>b. Perform an analysis of material capabilities or radiation test. |
| NEMA insulation class | Should be equal to or higher than original (ratings from low to high: A, B, F, H, RH). | If motor is normally de-energized (energized less than 20% of the time), it may be acceptable. Motor life will be shorter if it is continuously energized. | Verify that the winding rating is equal to or higher than that of the original. If motor is normally de-energized, lower rating is acceptable—if energized accident use period at elevated temperature is short. |

**Table G-18**
**Attributes of Terminations That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Type and configuration of termination | Prevent moisture from shorting connections. | Open terminal blocks may be acceptable for HELB area applications if condensing moisture does not run across the terminal block and cannot accumulate around it.<br>Taped, heatshrink, and coldshrink splices are acceptable. | Temperature-/Radiation-Only Application:<br>Moisture is not a concern. Standard terminations are acceptable.<br><br>HELB-Area Applications:<br>The termination method should be the same configuration and materials or proven to be equal or better with respect to moisture withstand. If open terminal blocks are used, conduits should drain away from the motor housing. |

**Table G-19**
**Attributes of Lubrication That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| There is no significant issue for lubricants commonly used. | | | Outside containment does not present a significant concern for lubricant with respect to moisture, temperature, and radiation. |

### *G.1.4 Relays and Contactors (Outside Containment)*

Note: This subsection does not apply to protective relays.

Relays and contactors open or close set(s) of contacts when the operating coil is energized. The energization of the coil causes the armature that carries the moving contacts to change position. Relays and contactors are generally used in dry areas. However, the cabinets in which they are located may be subject to HELB environments. Certain relays have pneumatic dampers that delay armature motion on either energization or de-energization of the coil. Other relay types have electronic time delay circuits that control contact motion upon energization or de-energization. Contactors do not have such devices but may be equipped with auxiliary contacts that are used to indicate the position of the main contacts. Relays and contactors are located inside load centers, switchgear, and panels, which prevent the direct impingement of steam if located in HELB areas. Moist conditions following a HELB are not significant as long as terminations are not subject to heaving wetting that would bridge the terminals. Moisture films alone will not cause flashover (see Tables G-20 through G-23).

**Table G-20**
**Attributes of Coil and Lead Insulation That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Temperature rating | The temperature rating of the coil will affect operating life. | | The temperature rating should be equal to or greater than that of the original coil. |
| Materials of construction | | | For areas with greater than 100 krads TID, Teflon should be excluded from use. |
| Temperature rise | Increases in temperature rise will adversely affect the life of the coil and surrounding organic materials. | | Continuously Energized Coils: Temperature rise should be equal to or less than that of the original coil.<br>Normally De-Energized Coils: Temperature rise is of little or no concern. |

**Table G-21**
**Attributes of Organic Structural and Contact Support Components (Relays Only) That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Material must have equal or better thermal and radiation characteristics. | Different materials can cause differences in thermal and radiation aging. | Electrical properties of organic materials used in relay and contactor construction degrade after severe deterioration of mechanical properties. Therefore, mechanical deterioration is of higher concern than electrical deterioration. | All Applications:<br>If exposed to greater than 100 krads, exclude use of Teflon components.<br><br>Normally Energized:<br>Material temperature ratings should be equal to or greater than those of the original.<br><br>Normally De-Energized:<br>Thermal aging is not a concern. |

**Table G-22**
**Attributes of Electronic Circuits (If Applicable) That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Semi-conductor should exhibit the same electrical properties when exposed to radiation. | Concern only if used in radiation zone with radiation above 1000 rads. | | Confirm with manufacturer that different component has no effect on radiation capability.<br><br>Analyze circuit. If no complementary metal oxide semiconductor (CMOS), MOS, or digital components, component is acceptable to 10,000 rads.<br><br>An operability test following radiation exposure may be performed. |
| Temperature rating of the electrolytic capacitors. | Electrolytic capacitors may limit circuit life. | | Confirm that replacement capacitor has equal or higher temperature rating. |

**Table G-23**
**Attributes of Pneumatic Time Delay (Pneumatic Relays Only) That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Chemical and physical properties of the diaphragm material | Material change can alter aging characteristics and timing rate at peak temperature. | | If peak temperature required is beyond manufacturer's specified operating limit, ask if peak temperature has an adverse effect, or perform an operability test at peak temperature.<br><br>Aging is of little concern if continuously de-energized. Period time testing of relay will indicate if diaphragm is aging. |

## G.2 Electronic Devices

### *G.2.1 Pressure Transmitters*

Electronic pressure transmitters are used to measure gauge or differential pressure. Pressure transmitters may also be used to sense level and flow. A number of different designs convert the pressure signal to a 4–20 mA or 10–50 mA proportional current. The electronics and mechanical components that perform this conversion must be protected from steam and moisture intrusion if part of the accident condition. Accordingly, the housing and associated seals must be suitable for the accident pressure. In addition, the electronics and other components must be able to withstand accident temperature and radiation without failing and without large calibration shifts (see Tables G-24 through G-27).

**Table G-24**
**Attributes of Electrical Housing (Pressure Boundary of Electronics and Termination Cavities) That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| If sealed, housing must have sufficient strength to withstand accident pressure without collapsing as indicated by the thickness and type of material of construction. | a. Used outside containment<br><br>b. Used inside containment | a. Housing should provide suitable physical protection for coil and other electrical components.<br><br>b. If sealed, housing must be able to withstand accident pressure. | a. NEMA 1 through 4 are acceptable.<br><br>b. Housing should have pressure rating equal to or higher than that of the original housing. |

**Table G-25**
**Attributes of Electrical Housing Cover Seals (Electronics and Termination Cavities) That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| If housing is sealed, seal must exhibit proper hardness and resilience. | Used outside containment | The seal should be adequate to keep out dirt and condensation. | The seal should be adequate to support NEMA-4 pressure withstand. Silicone rubber and EPR are generally acceptable as seal gaskets or O-rings. Compare durometry results for seal materials. |

**Table G-26**
**Attributes of Electrical Port Seals (If Required) That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| If housing is sealed, seal must exhibit proper hardness and resilience. | a. Used outside containment (HELB areas) | a. Option 1: Thread sealant on conduit connection and conduit draining from device is adequate.<br>Option 2: Thread sealant on conduit connection and RTV or epoxy seal on conduit if top entry to device. | a. For HELB areas, electrical conduit should drain away from device. If not, require moisture seal at or near electrical entrance to SOV (for example, epoxy or RTV). |
| | b. Used in radiation-/temperature-only areas | b. Seal is not required. | b. No action is needed. |
| | c. Used inside containment | c. If required to complete seal, full LOCA-proof seal needed. | c. Full pressure barrier seal on port is necessary. |

**Table G-27**
**Attributes of Electronics and Mechanical Components of Mechanism That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Configuration and material strength of operating mechanism components. | Changes in materials (organic or metal) or configuration of mechanism may change calibration characteristics or cause failure at elevated temperature. | Significant calibration shift could cause improper system operation or confusion to the operator. | Determine if manufacturer has operating data covering peak temperature condition, or perform an operability test at required temperature. |
| Material of electronic components must have equal or better thermal and radiation characteristics. | Changes in circuit design or component types can affect calibration or function at elevated temperature or radiation dose. | Significant calibration shift could cause improper system operation or confusion to the operator. | Determine if manufacturer has operating data covering peak temperature condition and/or data covering required integrated dose, or perform operability test at required temperature and/or irradiation dose, or analyze components for susceptibility to radiation. |

### *G.2.2 Power Supplies (Outside Containment)*

Power supplies are generally not built to withstand moist environments. They may also have built-in thermal protection that causes the electronic circuit to shut down if overheating from load or ambient temperature occurs. Control circuits may contain digital components of MOSs that are sensitive to radiation. Electrolytic capacitors may limit operation life. Junction temperatures of power electronics (such as silicon-controlled rectifiers [SCRs], power diodes, triacs, and thyristors) have limits to prevent the junction from burning out. High temperatures are caused by ohmic heating of the junction plus the ambient temperature. Unless the manufacturer builds the power supply for moist applications, power supplies should not be exposed to HELB environments unless contained in a protective enclosure (see Tables G-28 through G-31).

**Table G-28**
**Attributes of Housing Openings and Vents That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Configuration of the housing that affects venting | Housing may be necessary to prevent electronics from shutting down or failing in moist conditions. | | Temperature-/Radiation-Only:<br>No concern; housing concerns relate only to physical protection of circuit and personnel.<br><br>HELB Environment:<br>Housing must preclude moisture entry, device must be manufactured to be moisture resistant, or power supply must be mounted in a housing that precludes moisture entry. |

**Table G-29**
**Attributes of Thermal Rating of Power Supply and Subcomponents That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Manufacturer's temperature rating | Temperature rating may be directly related to that of the junctions of the semi-conductors or to thermal protective devices within the power supply. | Temperature rise of power supply coupled with ambient temperature will limit peak temperature under which power supply will operate. | Verify that peak ambient temperature is within the limits of the power supply (refer to manufacturer's literature or discuss with manufacturer). Note: Use of an oversized power supply may reduce operating temperature of power semi-conductors. However, the main output circuit may not be the limitation. An on-board power supply for control of the overall power output may be the limiting component. Such a power supply is not greatly affected by reducing overall power throughput.<br><br>Operational testing in an oven at peak temperature may be performed to confirm operability at elevated temperature. |

**Table G-30**
**Attributes of Electronic Components That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Changes in circuit design and components affecting performance of the circuit | Analog electronics if frequently being changed to digital design. Different styles of control circuits may be employed to have the same overall function. | For environments including radiation, changes to electronic components may affect function. | For doses above 1000 rads, radiation capability of the power supply should be confirmed.<br>Perform an analysis that indicates no use of MOS and that digital control circuits will be used to at least 10,000 rads.<br>Operability tests following a radiation exposure may be performed. |

**Table G-31**
**Attributes of Electrolytic Capacitors That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Temperature ratings of electrolytic capacitors | The temperature rating of electrolytic capacitors will affect the operating life of the power supply. | Electrolytic capacitors are contained in the control power circuit for the power supply as well as in the output filtering circuit. Either may limit power supply life. | Temperature ratings of electrolytic capacitors must be equal to or greater than those of the original capacitors. Otherwise, power supply life may be shortened significantly. |

## G.3 Passive Electrical Devices

### *G.3.1 Temperature Elements (Resistance Temperature Detectors) and Thermocouples*

RTDs and thermocouples use similar housings and termination systems and have similar environmental concerns (see Tables G-32 through G-35).

**Table G-32**
**Attributes of Head-to-Element-Thread Sealant That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Material must have equal or better thermal and radiation characteristics. | Prevents pressurized steam from entering electrical cavity | | Inside Containment:<br>Use of thread sealant is important and must not fail at given temperature and radiation conditions.<br><br>Outside Containment:<br>Thread sealant should be present but is not critical to the function due to transient low-pressure conditions. |

**Table G-33**
**Attributes of Electrical Housing Compartment Seal and Thread Sealant That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Material must have equal or better thermal and radiation characteristics and be of the same configuration. | Prevents pressurized steam from entering electrical cavity | | Inside Containment:<br>Seal is important to accident function. Seal assembly suitable for temperature, radiation, and pressure conditions is needed.<br>Outside Containment:<br>Thread sealant should be present but is not critical to function due to transient low-pressure conditions. Conduit seal not needed if conduits drain away from housing. |

**Table G-34**
**Attributes of Lead Insulation That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Material must have equal or better thermal and radiation characteristics. | Insulation on leads between the element and termination must not crack or fall off. | Lead insulation must be capable of withstanding conductive and radiant temperature effects from the process as well as radiation and temperature from ambient conditions. | Inside Containment:<br>Do not use Teflon. Other high-temperature insulations (such as Kapton and PEEK) may be acceptable.<br>Outside Containment:<br>Do not use Teflon above 100 krads. Other materials are acceptable for radiation. High-temperature insulation is necessary for steam or high-temperature water process mediums. |

**Table G-35**
**Attributes of Termination Insulation That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Material must have equal or better thermal and radiation characteristics and be of the same style. | | Termination style and insulation type are generally critical for inside-containment use.<br><br>Open terminal blocks may be acceptable for HELB area applications if condensing moisture does not run across the terminal block and cannot accumulate around it.<br><br>Taped, heatshrink, and coldshrink splices are acceptable. | Inside Containment:<br>Terminal blocks should not be used to replace heatshrink splices. Note: Some applications require that the entire electrical cavity be potted after terminations are made.<br><br>Outside Containment:<br>Temperature-/radiation-only applications: Moisture is not a concern. Standard terminations are acceptable.<br><br>HELB-Area Applications:<br>The termination method should be the same configuration and materials or proven to be equal or better with respect to moisture withstand. If open terminal blocks are used, conduits should drain away from the electrical housing. |

## G.4 Connecting Devices

### *G.4.1 Terminal Blocks (Outside Containment)*

The configuration of a terminal block, its material, and its installed orientation can all affect function under condensing moisture conditions. This section (Tables G-36 and G-37) assumes that an existing terminal block is being replaced with a terminal block of similar shape and in the same orientation such that the protection and the support and housing characteristics of the original installation continue to exist (for example, protection from water running directly across the terminal block from condensation).

**Table G-36**
**Attributes of Organic Material That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Material must have equal or better thermal and radiation characteristics. | The material provides the support for the terminations and insulation between individual terminations and between terminations and ground. | High-temperature phenolics should not be replaced with materials with lower temperature ratings unless the application has low normal and accident temperatures. | All Applications:<br>If radiation dose exceeds 100,000 rads, exclude the use of Teflon.<br><br>I&C Applications:<br>The temperature rating of the material must exceed the peak accident temperature for the application. If the replacement material is thermoplastic, the melt point must be at least 20°F above the peak accident temperature or manufacturer's information, or operability test at the peak temperature must be available.<br><br>Power Applications:<br>Same as above, but temperature rise from ohmic heating of the terminal block must be added to ambient temperature when performing the assessment. |

**Table G-37**
**Attributes of Configuration of Terminal Block That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Terminal block configuration | Differences in configuration under wet conditions from a HELB can allow tracking paths to occur that would allow shorts between terminations or between terminations and ground. | | Temperature-/Radiation-Only: Configuration differences are not of concern.<br><br>HELB-Area Applications: Differences must be considered to the extent that applications can have water accumulate on terminal block surfaces. If water does not reach terminal block surface in applications (for example, water from above is not a concern or drip shields and drip loops are used), alternate configurations would be allowed. Otherwise, different configurations must be carefully considered for the bridging of terminations from water accumulation caused by dripping or condensation on wiring. |

### G.4.2 Splice Coverings (Outside Containment)

Taped and heatshrink-sealed splices outside containment are subject to much less severe accident conditions than those inside containment. In temperature-/radiation-accident environments, splices essentially must provide “standoff” separation (that is, they must hold the conductors far enough apart so that dry air would be the insulator). Under a HELB environment, the pressure is low and transient such that significant moisture cannot be forced into the splice. Rather, the splice must protect from moisture that accumulates from condensation during the event (see Tables G-38 and G-39).

**Table G-38**
**Attributes of Organic Material That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Material must have equal or better thermal and radiation characteristics. | The material provides electrical separation between adjacent conductors and between conductors and ground. | The insulation must be capable of withstanding ohmic heating of the splice during operation coupled with ambient temperature of normal and accident conditions. The mechanical properties of the insulation deteriorate prior to electrical degradation if sealing occurred when the splice was prepared (that is, a moisture path did not exist from the time of construction). | All Applications:<br>If radiation dose exceeds 100,000 rads, exclude use of Teflon.<br>For heatshrink splices, verify that peak temperature (and temperature rise, if applicable) does not cause significant additional shrinkage of material that could lead to splitting (control of use ranges should preclude this condition).<br><br>I&C Applications:<br>The temperature rating of the material must exceed the peak accident temperature for the application.<br>If the replacement material is thermoplastic, the melt point must be at least 20°F above the peak accident temperature or manufacturer’s information, or operability test at the peak temperature must be available unless thermoplastic material does not provide physical protection (for example, outer jacket material provides separation and protection).<br><br>Power Applications:<br>Same as above, but temperature rise from ohmic heating of the terminal block must be added to ambient temperature when performing the assessment. |

**Table G-39**
**Attributes of Splice Configuration That Can Affect Accident Function**

| Part Attribute Affected by Harsh Environmental Condition | End Use Application Considerations | Comments | Actions to Resolve Differences |
|---|---|---|---|
| Splice configuration | Configuration differences (for example, a different number of conductors being connected) may prevent adequate sealing. | | Temperature-/Radiation-Only:<br>Full sealing is not critical. Verify that usage range is correct and that sharp points on connection being terminated have adequate padding to prevent splitting of heatshrink splice materials when shrunk.<br><br>HELB-Area Applications:<br>Verify with manufacturer that seal will actually be made with new configuration (for example, overlaps will be adequate and crotches between conductors will be adequately filled during splice assembly). |

# H
# EXAMPLES OF AFA DEVELOPMENT FOR NON-EQUIVALENT REPLACEMENT ITEMS

As described in Section 3, "Reasonable Confidence," the degree of effort required to establish an accident function basis is lower for outside-containment applications than for inside-containment applications. For outside-containment applications, the effort required to develop an accident function assessment is expected to be less for temperature-/radiation-only conditions and more for high-energy line break (HELB) conditions. To allow an accident function assessment to be developed, the service conditions under normal and accident conditions must be determined for the applications or group of applications.

Many RISC-3 components have been environmentally qualified per 10CFR50.49. Although a new device may not be identical to a device that has been previously qualified, some attributes may be similar to or the same as those of one or more qualified devices. The existing qualification may be used as part or all of the accident function assessment (AFA) for the similar portion(s) of the new device. For example, housings similar to those used on the electronics and termination cavities of a Rosemount transmitter are used on other electronic components. Accordingly, the Rosemount EQ could be used to establish the adequacy of a similar housing to protect against pressurized steam ingress. The interior components of the new device would not be proven to be acceptable by the Rosemount qualification report; however, their assessment would now be limited to radiation and thermal effects. Similar bases could be established for wiring and termination systems.

Up to 80% of the expected RISC-3 applications are expected to occur outside containment, where conditions for establishing an accident function basis are less demanding. Appendix G lists attributes of common components that can affect accident function. These attributes can also be used to construct an accident function basis. The following subsections describe possible paths for establishing the accident function assessments for a few typical devices. These examples assume that the basic design attributes for the application have been found acceptable and that the only area of interest is the development of the accident function assessment. In addition, the examples provide an indication of the degree of effort required to attain reasonable confidence in the performance of accident function. EPRI neither recommends nor promotes the product manufacturers described in the following examples. The devices assessed were chosen based on availability of information on the manufacturers' web sites and not because of any specific merit or capability. The environments used in the examples are not necessarily applicable to any RISC-3 application.

## H.1 Solenoid-Operated Valve AFA Example: Outside-Containment, High-Energy Line Break Area

**1. Accident conditions**

- Peak temperature: 230°F (110°C)
  Duration: 10 minutes (return to normal within 24 hours)
- Peak pressure: 1 psig
  Duration: 30 seconds and return to atmospheric
- Maximum radiation: 1 Mrd (separate event from HELB)
  (normal plus accident total integrated dose [TID])

**2. Normal Conditions**

- Normal temperature: 90°F (32°C).
- Process temperature: <120°F (<48.8°C).
- Process medium: Dry, compressed air (minimal oil, minimal water).
- Operating mode: Some valves are continuously energized and others are normally de-energized.

**3. Device Description**

This accident function assessment is being developed for an Atkomatic two-position, two-way valve, direct lift Series 3000 valve, Number 3108-300P2CC1W.

Note: EPRI has used this valve as an example to demonstrate the development process for a RISC-3 accident function assessment. EPRI makes no claim concerning the adequacy of this device for use in a RISC-3 application.

**4. Attributes**

The following attributes are based on catalog selection options. The attributes relate to the overall specification for the valve. The items in **bold face** are those that can affect accident function; the other attributes do not directly affect accident function.

- Valve body: bronze
- Pipe thread size: 3/8 in.
- **Coil classes available**: H and B (H selected)
- Coil voltage: 24–380 Vac, 12–250 Vdc (125 Vac selected)
- Connection type: NPT
- Orifice size: 1/16 to 3/8 in. (3/32 in. selected)

- **Seats available**: Buna, Viton, ethylene propylene diene monomer (EPDM), Teflon, Kel-F, stainless steel, brass (Viton or EPDM may be selected)
- **Body seal materials available**: Buna, Viton, EPDM, Teflon (Viton or EPDM may be selected)
- **Fluid medium**: Air
- **Electrical housing system**: NEMA Class 4 waterproof

**5. Assessment of Environmental Capability**

Note: Most of the information necessary to develop the accident function assessment for this device was obtained from the manufacturer's web-based catalog.

*Environmental Seal*

The ambient environment pressure for these outside-containment valves peaks at 1 psig and has a 30-second duration. The valve has two seal systems: one for the valve body and one for the coil housing.

The valve body separates into two sections with a threaded connection. The seal is formed by an O-ring body seal. Although four different materials are offered, either Viton or EPDM should be selected (this selection is described below). The pressure rating for the valve grouping for air is a minimum of 400 psi. The maximum environmental pressure is 1 psig. Accordingly, there is no concern with pressure forcing moisture from the HELB into the valve body.

Four different types of coil housing are available. The NEMA Class 4 housing was selected because it will withstand a 1-psig pressure without cause for ingress of moisture. Note that if the coil is normally energized prior to the HELB, ingress of moisture is highly unlikely due to the elevated temperature of the coil (for example, condensation on the hot coil is unlikely). If conduits drain away from the SOV, no seal at the electrical entrance to the coil housing is necessary. If conduits drain toward the coil housing, a high-temperature RTV silicone rubber or epoxy seal may be applied.

*Coil*

If the valve is to be continuously energized, the Class H coil should be used to ensure long life. The coil is rated for a 185°C (333°F) rise in a 25°C (77°F) ambient environment. The related Class B coil is rated for 155°C (279°F) in a 25°C (77°F) environment and is stated as being suitable for 104°C (220°F) process temperatures. The Class H coil provides an exceedingly long life for this application given a maximum 32°C (90°F) ambient temperature and a maximum process temperature of 49°C (120°F). The 185°C (333°F) rise rating in a 25°C (77°F) ambient is designed to provide a 30,000-hour (3.4-year) life when continuously energized (see page 96 of *Atkomatic Solenoid Valves Catalog* [H.1.1]). The 185°C (333°F) rise in a 25°C (77°F) ambient environment equates to a 210°C (410°F) allowable hotspot temperature. The peak accident ambient temperature is 110°C (230°F) with a short duration (10-minute peak return to normal within 24 hours). This peak temperature will not challenge the coil significantly due to the large

temperature rise capability. From typical curves for a Class H insulation system (see Figure 6-75 of the EPRI report *Power Plant Electrical Reference Series, Volume 6: Motors* [EL-5036-V6] [H.1.2]), an operating temperature of 180°C (356°F) has a life of 100,000 hours (11.5 years). A 1-million-hour (114-year) life occurs at a coil temperature of 143°C (290°F). Given that the process temperature has a maximum temperature of 49°C (120°F) and the ambient temperature has a maximum of 32°C (90°F), an exceedingly long coil life would occur, given that the coil could have a temperature rise of more than 94°C (169°F) and have a life well in excess of the total life of the plant. The holding volt-amps for a 115-Vac coil is 67 Va (see page 94 of *Atkomatic Solenoid Valves Catalog* [H.1.1]). Given the low ambient and process medium temperatures, the coil hotspot temperature is unlikely to approach 143°C (289°F), and a coil life in excess of 60 years is expected, even with continuous energization.

Given the 1-Mrd dose associated with this application, the manufacturer should be contacted to confirm that no significant coil component (such as coil wire insulation or coil bobbin) is based on Teflon. Other coil components composed of Teflon may be acceptable, depending on their relation to accident function. (Contact the manufacturer to confirm that Teflon is not used in or can be excluded from the manufacture of the device.)

*Leads*

Given the required radiation dose of 1 Mrd and that the coil may be continuously energized, a high-temperature, radiation-resistant lead insulation is necessary. The lead information is not explicitly stated in the catalog material. Teflon should be excluded, and silicone rubber or EPDM would be acceptable. (Discussions with the manufacturer are necessary to confirm the presence of lead material.)

*Seats*

Although five different soft seat materials are available (Buna, Viton, EPDM, Teflon, and Kel-F), Teflon must be excluded due to its limited radiation resistance. Viton, EPDM, and Kel-F may be used because all of the materials are temperature resistant and will not be affected by the 1-Mrd TID [H.1.4]. The industry has more experience with Viton and EPDM. If the air system has a tendency to have oil carryover (some plants have oil misters for certain styles of damper operators), Viton is the appropriate choice because EPDM can be adversely affected by oil. Both EPDM and Viton have long thermal lives at the relatively low temperatures involved with these applications. Buna would produce a shorter life in continuously energized applications and should not be used.

*Body Seals*

Buna, Viton, EPDM, and Teflon body seals are available. Based on the previous discussion for “Seats,” either EPDM or Viton should be selected and would be satisfactory for long service.

*Overall Radiation Capability of Components*

Based on Figures B-2-1 through B-2-4 of the EPRI report *Guidance for Accident Function Assessment for RISC-3 Applications: Alternate Treatment to Environmental Qualification for RISC 3 Applications* (1009748) [H.1.3], with the exclusion of Teflon and Buna (after confirmation that Teflon is not used in the coil or as lead insulation), the organic materials used in these solenoid-operated valves (SOVs) are satisfactory for use to a radiation dose in excess of 1 Mrd.

*Thermal Aging*

As described previously, a Class H coil has been chosen, and EPDM or Viton seals and seats and silicone rubber or EPDM coil leads will be used. As stated in the individual component analyses, the service life of these solenoids well exceeds the remaining plant life, even when accident function capability is considered.

*Mechanical Cycling*

The applications are expected to cycle approximately once per month due to surveillance testing. This cycling rate is well within the capability of this industrial SOV.

**6. Summary of Accident Function Assessment**

The Atkomatic 3108-300P2CC1W two-way SOV is satisfactory for the outside-containment normal and accident HELB and radiation conditions described previously. There is reasonable confidence that the valve will perform its accident function through the end of its service life, which is expected to be in excess of 60 years. The EPDM (or Viton) body seals and valve seats will not be significantly stressed by the conditions of the applications. The Class H coil has been selected to withstand long-term energization.

**7. Maintenance, Surveillance, and Testing Requirements**

There are no maintenance, surveillance, or testing requirements for this device.

**8. Installation Requirements**

The valves must be installed within 10° of vertical per the manufacturer's installation requirements.

**9. Directions for the Procurement Organization**

Confirm that the leads and coil do not contain Teflon.

### 10. References for Assessment

H.1.1 *Atkomatic Solenoid Valves Catalog*, Circle-Seal Controls, Inc., Corona, CA. www.circle-seal.com.

H.1.2 *Power Plant Electrical Reference Series, Volume 6: Motors*. EPRI, Palo Alto, CA: 1987. EL-5036-V6.

H.1.3 *Guidance for Accident Function Assessment for RISC-3 Applications: Alternate Treatment to Environmental Qualification for RISC 3 Applications*. EPRI, Palo Alto, CA: 2005. 1009748.

H.1.4 *Radiation Data for Design and Qualification of Nuclear Plant Equipment*. EPRI, Palo Alto, CA: 1985. NP-4172SP.

## *H.1.1 Implementation of the Procurement Process*

The following describes how the procurement would proceed.

### Technical Evaluation

Based on the accident function assessment, an Atkomatic 3108-300P2CC1W2 two-way solenoid valve was determined to be suitable for the RISC-3 application. No alternate two-way solenoid valves were noted by the design organization as being equivalent alternate items; therefore, a sole-source procurement was justified. The supplier selected was Circle-Seal Controls, Inc. because the item required is unique to that manufacturer. Although either Viton or EPDM is a suitable seat and body seal material, the design organization selected EPDM based on the plant-specific RISC-3 application(s) for this device. A procurement requisition was prepared based on the item selected by the design organization.

1. The following technical information was specified to Circle-Seal Controls, Inc.:

   Atkomatic 3108-300P2CC1W2 two-way solenoid valve, coil Class H, furnished with EPDM seats and body seals.
   Note: Teflon material is not permitted.

2. The supplier is certified to ISO 9001, and, as such, the licensee opted to specify the following requirement:

   The Atkomatic 3108-300P2CC1W2 two-way solenoid valve shall be controlled in accordance with Circle-Seal Controls' ISO 9001 quality management system.

3. The following documentation was requested from Circle-Seal Controls, Inc.:

   - Supplier documentation certifying that PO requirements have been met
   - A copy of the supplier's ISO 9001 certification

**Acceptance Process**

A receipt inspection of the solenoid valve is conducted to visually inspect the following product attributes:

- Part number (should be Atkomatic 3108-300P2CC1W2)
- General condition of the item (ensure that the item is not damaged)
- Quantity (ensure that the quantity received matches the number specified)
- Outline configuration (compare to published product description outline drawing)
- Body seal and valve seat materials (ensure that supplier documentation indicates that furnished items are EPDM and not Teflon)

Verification of receipt of the following supplier-furnished documents:

- Documentation certifying that PO requirements have been met, including coil Class H designation and EPDM seal and valve seat material, and that no Teflon was furnished
- A copy of the supplier’s ISO 9001 certification

**Implementation of the Maintenance Process**

There are no maintenance requirements for this device.

**Installation Requirements**

The valves must be installed within 10° of vertical per the manufacturer’s installation requirements.

## H.2 Motor Accident Function Assessment Example: Outside-Containment, High-Energy Line Break Area

**1. Accident Conditions**

- Peak temperature: 230°F (110°C)
  Duration: 10 minutes (return to normal within 24 hours)
- Peak pressure: 1 psig
  Duration: 30 seconds and return to atmospheric
- Maximum radiation: 1 Mrd (separate event from HELB)
  (normal plus accident TID)

**2. Normal Conditions**

- Normal temperature: 120°F (49°C).
- Application: Fan cooler motor.

- Operating mode: Some motors are continuously energized and others are normally de-energized.
- Actual load: 3/4 hp.

**3. Device**

This accident function assessment is being developed for a Baldor Catalog Number M8003T Motor, Specification Number 05E056W493H1.

Note: EPRI has used this motor as an example to demonstrate the development process for a RISC-3 accident function assessment. EPRI makes no claim concerning the adequacy of this device for use in a RISC-3 application.

**4. Attributes**

The following attributes are based on catalog selection options. The attributes relate to the overall specification for the motor. The items in **bold face** are those that can affect accident function; the other attributes do not directly affect accident function.

- Horsepower/kilowatt: 1 hp/0.75 kw
- Voltage: 230/460 ac
- Hertz: 60
- Phase: 3
- Full load amps: 2.8/1.4
- RPM: 1740
- Frame size: 143T
- Service factor: 1.15
- **Rating: 104°F (40°C) ambient continuous**
- Locked rotor code: B
- **Insulation class: F**
- **Enclosure: totally enclosed fan cooled**
- **DE bearing: 6205**
- **ODE bearing: 6203**

**5. Environmental Capability Assessment**

Note: Most of the information necessary to develop the accident function assessment for this device was obtained from the manufacturer’s web-based catalog.

*Environmental Seal*

The ambient environment pressure for these outside-containment valves peaks at 1 psig and has a 30-second duration.

The motor has a totally enclosed, fan-cooled housing. As such, the 1-psig transient pressure condition will cause an extremely small amount of moist air to enter the housing only at the shaft bearing. The duration of the pressure condition is 30 seconds and can allow only a small amount of damp air to enter the housing cavity. The air internal to the motor is very dry due to motor operational heating that drives moisture out. Accordingly, the pressure condition will cause, at most, the interior of the motor to have humid air but not a condensing moisture condition. Such a condition is not adverse to function of the motor.

The lead box has a bottom conduit entry. No seal is necessary if the conduit drains away from the motor. If the conduit drains toward the motor, an RTV silicone rubber seal should be placed at the entrance to the motor connection box to prevent moisture from accumulating in the box during a HELB.

*Winding*

The winding has been chosen as a Class F with the capability of a 311°F (155°C) temperature rating (see Figure 6-75 in the EPRI report *Power Plant Electrical Reference Series, Volume 6: Motors* (EL-5036-V6) [H.2.2]. The Class F winding provides an exceedingly long life for this application given a maximum 120°F (49°C) ambient temperature. The actual motor load is 3/4 hp, while the rating of the motor is 1 hp. According to Table 6-2 in EPRI Report EL-5036-V6, the expected temperature rise at full load is 189°F (105°C) [H.2.2]. At a 3/4-hp load, the rise from ohmic heating will be approximately 59°C ($[3/4]^2$ x 105°C), resulting in a very long winding life and a large capability to withstand thermal transients such as those that occur at the onset of a HELB. The expected winding temperature is 108°C (49°C ambient + 59°C rise). Per Figure 6-75 of the EPRI report EL-5036-V6, the life of the winding at 108°C is expected to be well in excess of 1 million hours (114 years) [H.2.2]. This degree of conservatism in winding life (maximum necessary life of 52 years[18]) allows the motor to have a large amount of thermal and radiation capability to withstand the HELB transient and the accident radiation conditions possible for the RISC-3 application.

Given the 1-Mrd dose associated with this application, the manufacturer should be contacted to confirm that no significant coil component is based on Teflon. (Contact the manufacturer to confirm that Teflon is not used in or can be excluded from the manufacture of the device.)

[18] The maximum remaining life of any current nuclear plant is less than 52 years.

*Leads*

Given the required radiation dose of 1 Mrd and that the coil may be continuously energized, a high-temperature, radiation-resistant lead insulation is necessary. The lead information is not explicitly stated in the catalog material. Teflon should be excluded. Silicone rubber or EPDM would be acceptable. (Discussions with the manufacturer are necessary to confirm lead material.)

*Bearings*

The EPRI report *Power Plant Electrical Reference Series, Volume 6: Motors* (EL-5036-V6), Figure B-2-5 describes the radiation resistance of lubricants [H.2.2]. The figure indicates that a 1-Mrd dose has no effect on lubricants. Accordingly, the 1-Mrd dose for this application will not significantly affect accident function. The low operating temperature for this motor will also support long bearing lubricant life.

*Internal Fan*

The material of the fan for cooling the motor is not stated. The fan may be metal or plastic. The material of the fan should be verified as being adequate for the peak HELB temperature. (Contact the manufacturer to determine the material used; if it is plastic, confirm that its temperature rating meets or exceeds the 230°F [110°C] peak HELB temperature.)

*Overall Radiation Capability of Components*

Based on Figures A-1 through A-4 of Appendix B of the EPRI report *Guidance for Accident Function Assessment for RISC-3 Applications: Alternate Treatment to Environmental Qualification for RISC-3 Applications* (1009748), with the exclusion of Teflon and Buna (after confirmation that Teflon is not used in the coil or as lead insulation), the organic materials used in these motors are satisfactory for use to a radiation dose in excess of 1 Mrd [H.2.3].

*Thermal Aging*

The analysis of the winding described previously indicates that the service life for this motor far exceeds the remaining life of the plant. The use of silicone rubber or EPDM leads will support the needs of this application.

*Mechanical Cycling*

The motors that are normally de-energized will be started once per month for surveillance testing. The normally energized applications will be stopped once per month during surveillance testing. The number of on/off cycles is limited and well within the capability of these motors.

### 6. Summary of Accident Function Assessment

The Baldor Catalog Number M8003T Motor is satisfactory for the outside-containment normal and accident HELB and radiation conditions described previously. There is reasonable confidence that the motor will perform its accident function through the end of its service life, which is expected to be in excess of 52 years. A slightly oversized motor with a Class F winding has been selected to withstand long-term energization and any thermal effects of a HELB condition.

### 7. Maintenance, Surveillance, and Testing Requirements

This device should be replaced after 52 years of service. When the connected component is serviced, the general condition of the motor should be observed and any adverse conditions rectified.

### 8. Installation Requirements

This motor should be mounted horizontally (that is, shaft axis horizontal). A flexible conduit that drains away from the motor shall be used. Motor terminations may be connected to internal terminal barriers.

### 9. Directions for the Procurement Organization

Confirm that the winding and leads do not contain Teflon.

Confirm the material of construction of the motor fan. If plastic, confirm that the material has a temperature rating of at least 230°F (110°C).

### 10. References for Assessment

H.2.1 *Baldor Electronic Catalog Sheet for Motor M8003T*. Baldor Electric Company, Fort Smith, AR. 2004.

H.2.2 *Power Plant Electrical Reference Series, Volume 6: Motors*. EPRI, Palo Alto, CA: 1987. EL-5036-V6.

H.2.3 *Guidance for Accident Function Assessment for RISC-3 Applications: Alternate Treatment to Environmental Qualification for RISC-3 Applications*. EPRI, Palo Alto, CA: 2005. 1009748.

### *H.2.1 Implementation of the Procurement Process*

The following describes the procurement process.

**Technical Evaluation**

Based on the accident function assessment, a Baldor Catalog Number M8003T motor was determined to be suitable for the RISC-3 application. No alternate motors were noted by the design organization as being equivalent alternate items; therefore, a sole-source procurement is justified. The supplier selected was Baldor Electric Company because the item required is unique to that manufacturer. A procurement requisition was prepared based on the item selected by the design organization.

1. The following technical information was specified to Baldor Electric Company:

   Baldor Catalog Number M8003T motor, Specification Number 05E056W493H1, Class F coil winding, furnished with either silicone rubber or EPDM lead material

   Notes: Teflon material is not suitable for use in the coils or as lead insulation. Confirm the lead material used. Confirm the material of construction of the motor fan. If plastic material is used for the motor fan, it must have a temperature rating of at least 230°F (110°C).

2. The following documentation was requested from Baldor Electric Company:

   Supplier documentation certifying that PO requirements have been met, including coil Class F designation, type of lead material furnished (either silicone rubber or EPDM; no Teflon was furnished), and the temperature rating of at least 230°F (110°C) for plastic parts used in the fan, if any.

**Acceptance Process**

A receipt inspection of the solenoid valve is conducted to visually inspect the following product attributes:

- Part number (should be Baldor Catalog Number M8003T)
- General condition of the item (ensure that the item is not damaged)
- Quantity (ensure that the quantity received matches the number specified)
- Outline configuration (compare to published product description outline drawing)

Verification of receipt of the following supplier-furnished documents:

- Documentation certifying that PO requirements have been met, including coil Class F designation, type of lead material furnished (either silicone rubber or EPDM; no Teflon was furnished), and the temperature rating of at least 230°F (110°C) for plastic parts used in the fan, if any.

## Implementation of the Maintenance Process

This device should be replaced after 52 years of service. When the connected component is serviced, the general condition of the motor should be observed and any adverse conditions rectified.

## Installation Requirements (Mounting)

This motor should be mounted horizontally (that is, shaft axis horizontal). A flexible conduit that drains away from the motor shall be used. Motor terminations may be connected to internal terminal barriers.

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