Oconee Electrical Component Integrated Plant Assessment and Time Limited Aging Analyses for License Renewal

Revision 1

Technical Report

Oconee Electrical Component Integrated Plant Assessment and Time Limited Aging Analyses for License Renewal

Revision 1

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Final Report, August 2000

EPRI Project Manager
J. Carey

EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

ORGANIZATION(S) THAT PREPARED THIS DOCUMENT

Duke Power Company

Ogden Environmental and Energy Services Co., Inc.

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Requests for copies of this report should be directed to the EPRI Distribution Center, 207 Coggins Drive, P.O. Box 23205, Pleasant Hill, CA 94523, (800) 313-3774.

CITATIONS

This report was prepared by

Duke Energy Company
P. O. Box 1006
Charlotte, NC 28201

Principal Investigator
R. P. Colaianni

Special Assistance was received from
W. M. Denny
Ogden Environmental and Energy Services Co., Inc.
Philadelphia Operations
1777 Sentry Parkway West
Abington Hall, Suite 300
Blue Bell, Pennsylvania 19422

R. J. Smith
Duke Energy Company
P. O. Box 1006
Charlotte, NC 28201

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TECHNICAL WORK LEVEL OF DETAIL

The intent of this work is to satisfy the technical requirements of §54.21(a). As such, the level of detail for this work has been selected such that it satisfies those requirements but purposely does not go beyond those requirements. The level of detail selected provides reasonable assurance of continued intended function rather than absolute assurance. The NRC Commissioners accepted reasonable assurance as the standard to meet for maintaining intended function. As stated in the Statement of Considerations (SOC) that accompanied the publication of 10 CFR 54 [Reference 1]:

> **SOC for 10 CFR 54, Section III.f.(ii), The IPA Process (60FR22479)**
>
> *The Commission agrees with DOE that the IPA process is not intended to demonstrate absolute assurance that structures or components will not fail, but rather that there is reasonable assurance that they will perform such that the intended functions, as delineated in §54.4, are maintained consistent with the CLB.*

All technical work in this document has been prepared to provide this reasonable assurance level of detail.

REPORT SUMMARY

Duke Power Co. and Baltimore Gas and Electric Co. were the first two utilities to apply for and obtain license renewal for their nuclear units. This report is one in a series of EPRI reports providing the technical basis for the Oconee and Calvert Cliffs License Renewal Applications.

Background
License renewal is an important option many utilities operating nuclear power plants are currently considering. *Requirements for Renewal of Operating Licenses for Nuclear Power Plants* (10 CFR 54) describes the renewal process and provides the requirements for the contents of a license renewal application. This rule requires that utilities complete an Integrated Plant Assessment (IPA) when applying for a renewed operating license. The IPA, as described in 10 CFR 54.21, is an assessment that demonstrates the effects of aging on specific structures and components will be managed during the period of extended operation.

In addition to the IPA, the license renewal rule focuses on Time-Limited Aging Analyses (TLAAs). As defined in 10 CFR 54.3, these analyses are typically the boundary conditions and assumptions within the current licensing basis (CLB), specifically linked to 40 years of operation.

Objectives
To provide the electrical component review portions of the Oconee Nuclear Station IPA and TLAAs in accordance with 10 CFR 54; to provide the electrical component data used as the technical basis for information submitted to the Nuclear Regulatory Commission (NRC) as part of the Oconee License Renewal Application of July 1998.

Approach
This report is a revision to the previously published EPRI report TR-107527. The current revision includes changes that have been necessitated by interaction with the NRC. The document now represents the final agreements and understandings between the NRC and Duke regarding electrical components.

The report is composed of two parts. Part 1 contains information pertaining to the electrical component IPA as required by § 54.21(a):

- Identification and listing of those electrical components subject to an aging management review (AMR); § 54.21(a)(1).

- Description and justification of the methods used to identify and list those electrical components subject to an AMR; § 54.21(a)(2).

- Demonstration that the effects of aging for each identified electrical component will be adequately managed so that the intended function will be maintained consistent with the CLB for the period of extended operation; § 54.21(a)(3).

Part 2 contains information pertaining to the electrical component TLAAs as required by § 54.21(c):

- List of all electrical component TLAAs; § 54.21(c)(1).

- Demonstration for each electrical component TLAA that the analysis remains valid for the period of extended operation, the analysis has been projected to the end of the period of extended operation, or that the effects of aging on the intended function will be adequately managed for the entire period; §§ 54.21(c)(1)(i), (ii), (iii).

Chapter 1 of each part of the report describes how the utility met these requirements.

Results
This report documents the basis for the conclusion that plant managers have identified all Oconee electrical components subject to aging management review. It also describes how they will manage the components to maintain their intended functions consistent with the CLB for the period of extended operation. In addition, it documents the basis for the conclusion that plant managers have identified and satisfactorily evaluated all TLAAs for the period of extended operation.

EPRI Perspective
This report serves as an example of one approach to the problem of reviewing electrical components for license renewal to aid others preparing technical information for the same purpose. Providing the technical basis for the early license renewal applications will simplify the efforts required by future license renewal applicants to comply with the requirements of the License Renewal Rule. Related EPRI reports on license renewal include the following: *Calvert Cliffs Nuclear Power Plant License Renewal Application Technical Basis* (TR-106843*), Calvert Cliffs Nuclear Power Plant License Renewal Application* (TR-111031-CD)*, and Oconee Nuclear Station Application for Renewed Operating Licenses* (TR-111030-CD*).*

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ABSTRACT

The nuclear power plant license renewal rule, 10 CFR 54, *Requirements for Renewal of Operating Licenses for Nuclear Power Plants* [Reference 1], describes the license renewal process and provides the requirements for the contents of a license renewal application. In applying for a renewed operating license, this rule requires that an integrated plant assessment (IPA) be completed for Oconee Nuclear Station. The IPA, as described in 10 CFR 54.21, is an assessment that demonstrates the effects of aging on specific structures and components will be managed during the period of extended operation.

The Oconee IPA has been divided along engineering discipline lines traditional to Duke Power Company (Civil/Structural, Electrical and Mechanical). [Footnote 1] Dividing the work in this way facilitated the technical reviews consistent with the current Oconee technical information set. The technical information covering the IPA for each discipline is documented in Oconee station specifications.

In addition to the IPA, the license renewal rule focuses on time-limited aging analyses (TLAAs). As defined in 10 CFR 54.3, these analyses are typically the boundary conditions and assumptions within the current licensing basis specifically linked to 40 years of operation. Although some TLAA resolutions are contained in the Oconee IPA specifications, most are contained within specific TLAA specifications.

The IPA and TLAA specifications comprise the engineering input that forms the technical bases upon which the Oconee license renewal application is built. The Oconee license renewal application is currently being reviewed by the Nuclear Regulatory Commission staff to ensure compliance with 10 CFR 54.

At the conclusion of the license renewal process, the information contained in these specifications will be reviewed against and merged with the Oconee engineering information, as appropriate.

1. **Engineering Discipline Boundaries:** The discipline boundaries, with few exceptions, are as follows: if a component or parts of it carry electrical current it is Electrical; if it supports, protects or restrains the movement of a component, it is Civil/Structural; everything else is Mechanical. Exceptions to this are noted where applicable.

ACKNOWLEDGMENTS

Above all else, I would like to acknowledge Peg Odom, my wife, for her continued understanding and confidence in me and for providing a comfortable place to which I could come home after a day at the office or an out-of-town meeting dealing with the many license renewal issues over the past few years. Peg gets my special thanks.

This document was several years in the making. Along the way, I received information and assistance from several individuals. This is my first attempt at a document of this size and scope and I appreciate John Carey of EPRI and the EPRI Life Cycle Management Subcommittee for their patience and support.

When first joining the license renewal project, I had no clear vision of the path to a completed evaluation for electrical components. For the IPA, I played around with several approaches for evaluating electrical components and continually ran into huge time or cost barriers. A breakthrough came when I received a draft review copy of the DOE/Sandia cable aging management guide. That draft document described an approach for evaluating components based on spaces, not systems. I instantly saw the benefits of such an approach for my own license renewal work.

The DOE/Sandia cable aging management guide was being prepared by Ogden Environmental and Energy Services. Over the next several months I asked Ogden personnel numerous questions regarding the guide and its application. As a result of these discussions, I began a working relationship with the always helpful Bill Denny. Bill has been an immense help to me over the past couple of years in the areas of culling through station documents and databases to retrieve and organize data on components, component materials, and design plant environments. Bill assembled, organized, and summarized mounds of data related to Turbine Building temperature measurements and industry historical data of failures. Bill supplied the references for all materials aging information contained in this report and assisted in the self-heating calculations. Bill provided numerous sanity checks along the way and endured seeing much of his early work (all impeccable) trashed as the document organization and emphasis changed; and changed; and changed; and changed.

The NEI License Renewal Electrical Working Group was started in an effort to provide a forum for discussion and resolution of license renewal electrical component issues. The initial group task culminated in the list of electrical component types and their basic functions. This led to the documentation of §54.21(a)(1)(i) determination contained in this report for all electrical component types. This was the first attempt at providing a complete list of component types and a documented basis for the determination. The initial group of individuals involved in this work were Boris Gan of GPU Nuclear, Paul Thomas of PECO, Jeff Mulvehill of Southern Nuclear, Carl Yoder of BG&E, and Tony Ploplis of Entergy. I appreciate the contribution of each of these individuals to the results documented in this report.

As part of the Duke in-house IPA review process, Thamir Al-Hussaini and Steve Graham spent many hours reviewing the details of the insulated cables and connections chapter. Their diligent reviews and hard questions led to a much stronger review.

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Robert Knoerr was the checker for the IPA specification. He is the one person who would not let me get away with unsupported statements or slack reasoning.

Bob Smith, Duke's Environmental Qualification expert deserves special mention. Bob went beyond his usual hectic work schedule to complete all of the calculations which reviewed electrical component TLAAs. My work was minimal in this area as I only summarized the work Bob performed.

I would also like to thank the other engineers on the Oconee License Renewal Project who reviewed drafts of my work and helped me drive quality and consistency into the information contained in this report—Bob Gill, Debbie Keiser, Mike Semmler, Rounette Nader and Terry Cox.

Above the others on the technical side, I would like to thank the Manager of the Oconee License Renewal Project, Greg Robison. When I joined the project, Greg gave me all the paper work he had been collecting for years on electrical components and gave me free rein on how I should complete the evaluation for electrical components. Greg supported my involvement in the various groups and meetings that have helped me build relationships with key people in the industry. Before I joined the project, Greg was the kind of manager I wanted to have; now I know what its like to have one.

Paul Colaianni

CHANGES FROM THE FIRST PUBLICATION

This work was first published in EPRI TR-107527, which represented the Oconee electrical license renewal work as it existed upon submission of the license renewal application in July 1998. This document includes the changes that have taken place due to the NRC staff requests for additional information (RAIs), the NRC on-site inspections and numerous meetings that have taken place between the NRC and Duke. This document represents the final agreements and understandings between the NRC and Duke regarding electrical components. Many of the larger changes that took place are described below.

The initial electrical component scoping process eliminated electrical components from the aging management review (AMR) based on the classification of the structure supporting them. The accuracy of this approach was one of the main issues of concern in meetings with the NRC staff on October 22, 1998 and the week of October 26, 1998. In a Trip Report dated February 8, 1999 [Reference 2], the staff provides a summary of its review activities performed at the Duke offices from October 27, 1998 to October 30, 1998. The staff observed that the electrical system scoping and component screening process was confusing and difficult to follow. Several specific observations are documented in the Trip Report, which resulted in several staff requests for additional information (RAIs) in December 1998.

Although Duke continues to believe that using in-scope structures to identify the areas containing electrical components within the scope of license renewal is valid and can produce accurate results, Duke recognizes that the previous description of the electrical process may have been confusing and did contain unneeded complexity. To address the NRC staff trip report observations, Duke opted for a more conservative approach that no longer eliminates electrical components from the aging management review based on their being supported by a specific class of structure. The revised scoping process was provided to the NRC staff in the response to the electrical component RAIs [Reference 3, Attachment 3] and all appropriate sections of this document have been revised to include this information.

During the initial reviews the NRC staff also had problems with many of the terms used in the electrical reviews and most of these were modified to eliminate specific questions the staff had. The terms “functions,” “higher level system function” and “basic function” were replaced with “intended functions” wherever it is in reference to the §54.4(a) defined functions. The term “electrical component types” was replaced with “electrical component commodity groups” to match industry terminology. The term “bounding set” was replaced with “encompassing group” to match the term used in the 10 CFR 54 statement of considerations (SOC). The term “evaluation boundary” or “component evaluation boundary” were replaced with “component boundary” since the use of the word “evaluation” confuses the component boundary with the “system evaluation boundary” as used in NEI 95-10 Rev. 0. The term “I&C Applications” was replaced with “Non-power Applications” to eliminate confusion as to the distinguishing factor between it and Power Application insulated cables and connections, which are subject to significant self-heating.

All §54.4(a) scoping, §54.21(a)(1)(i) screening and §54.21(a)(1)(ii) screening discussions were pulled from the electrical component commodity group chapters and placed in separate chapters specific to each step early in the document. This leaves the component chapters dedicated to the list of what is included in the AMR. This also eliminated the electrical penetration assembly, line trap and uninsulated ground conductor chapters.

Very good progress has been made in the area of active/passive electrical component screening. Due to this progress the §54.21(a)(1)(i) screening determination section was reduced to eliminate unneeded discussions such as that concerning fuses.

Fire detector cables are no longer excluded from the AMR. The NRC staff position is that the testing would need to detect degradation. Failure detection is not considered by the staff to be an appropriate application of the §54.21(a)(1)(ii) criterion.

The *Insulated Cables and Connections Aging Management Program* was added (Section 7.7) as a result of the NRC on-site inspections. It is an inspection and testing program and the basis for which cables to include is discussed in Appendix C.

To better summarize the IPA a table was added (Table 14-1, Summary Results of the Oconee Electrical Component IPA).

Regarding electrical component TLAAs and the evaluation of Environmental Qualification components, Part 2 of this document has been updated to include the EQ Program Summary Description that was provided to the staff in response to an RAI. The NRC staff reviews and RAI did not translate to any technical or process changes in the review of EQ components.

ELECTRICAL COMPONENT REVIEWS

As part of the overall Oconee technical work, the electrical component specifications provide the methods used and the technical results of the electrical component IPA and TLAA reviews. The methods used are consistent with the guidance provided in NEI 95-10 (Revision 0) *Industry Guideline for Implementing the Requirements of 10 CFR Part 54 - The License Renewal Rule* [Reference 9].

The two Oconee station specifications that provide the technical information required by 10 CFR 54.21 for all the Oconee electrical components have been reproduced in this document with only minor changes.

This report serves as an example of one approach to the problem of reviewing electrical components for license renewal to aid others preparing technical information for the same purpose. The specific techniques used for the Oconee electrical IPA and TLAA evaluations have their fundamental basis in the document set available at Oconee. When possible, techniques were used that took advantage of existing information. Techniques that would require the generation of a lot of new material, such as a new database, were avoided where possible.

ACRONYMS AND DEFINITIONS

ACSR: aluminum conductor steel reinforced

adverse localized environment: a condition in a limited plant area that is significantly more severe than the specified service condition for the equipment.

AMG: aging management guide

AMR: aging management review

applicable aging effect: a net change in component characteristics (due to specific processes that gradually change characteristics of a component with time or use) that could cause the component to lose intended function prior to the end of the extended period of operation.

ASW: auxiliary service water

AWG: American Wire Gauge

AVA: a code for impregnated asbestos and varnished cambric (a very fine, thin linen or cotton cloth) insulation covered by asbestos braid or glass; an obsolete material which was deleted from the National Electrical Code in 1982-1983.

"b": graphical intercept for the line in an Arrhenius plot (related to material aging analysis)

Butyl: synthetic rubber (cable insulation or jacket material)

CCW: condenser circulating water

CFR: Code of Federal Regulations

CLB: current licensing basis

consumables/expendables: [Reference EPRI NP-6895, page 4-2, Project Q101-20, Final Report, February 1991, "Guideline for the Safety Classification of Systems, Components and Parts Used in Nuclear Power Plant Applications"] Materials and supplies used in the process of component operation or maintenance:

a) items that are expended during the operation of components/subcomponents or that are routinely replaced during the maintenance (e.g., diesel fuel, calibration standards, O-rings, gaskets, hydraulic fluid, lubrication oil, grease, packing and paint);

b) items that are expended in maintaining the chemical control of system process fluids (e.g., resins, additive chemicals and gases such as boron standard, pH buffer, branophenal blue and nitric acid); or

c) items that are expended during maintenance, installation and modification activities that are generally used throughout the plant and are not included in the above (e.g., solvents, layout fluid, leak-testing fluid, tape and penetrant testing materials) (NUREG-1000).

CPE: chlorinated polyethylene (cable insulation or jacket material)

CSPE: chlorosulfonated polyethylene (cable insulation or jacket material)

DBD: design basis document

DBE: design basis event

DOE: Department of Energy

DOR: Division of Operating Reactors

EHC: electro-hydraulic control

elongation: The increase in length produced in the gage length of the test specimen by a tensile load. It is expressed in units of length, usually inches. Elongation is also known as extension.

environmental conditions: ambient physical states surrounding a component

EP: ethylene propylene rubber (cable insulation or jacket material)

EPDM: ethylene propylene diene monomer (cable insulation or jacket material)

EPR: ethylene propylene rubber (cable insulation or jacket material)

EPRI: Electric Power Research Institute

EQ: environmental qualification

eV: electronvolt (the units for activation energy as related to material aging analysis)

FR: flame retardant, property of cable insulation or jacket material

FR-EPR: flame retardant ethylene propylene rubber (cable insulation or jacket material)

FR-XLPE: flame retardant cross-linked polyethylene (cable insulation or jacket material)

HELB: high-energy line break

HMWPE: high molecular weight polyethylene (cable insulation or jacket material)

HPSW: high-pressure service water

HVAC: heat, ventilation and air conditioning

Hypalon: DuPont Co. trade name for chlorosulfonated polyethylene (CSPE), (cable insulation or jacket material)

IPA: integrated plant assessment

IPCEA: Insulated Power Cable Engineers Association

Kapton: DuPont Co. trade name for one of its polyimide engineered thermoplastics (cable insulation material)

Kerite: a trade name of a proprietary compound, the basic components of which are a trade secret of The Kerite Company (cable insulation or jacket material)

LER: Licensee Event Report

LOCA: loss of coolant accident

MCM: thousand circular mils

Mean-Time-To-Failure: the average time between equipment breakdown or loss of service. Failure in this context means: After a thermal aging exposure, the wires were wrapped around a one-half inch diameter mandrel, placed in a mild salt solution (NaCl) and energized. A voltage was selected that represented a deterioration to 10-15 percent of the initial insulation breakdown voltage. Samples that survived a test cycle were re-exposed to successive test cycles until all ten specimens within a group have failed. Failures were defined as those combined stresses that cause wire insulation to crack through to the conductor when bent, to fail the dielectric withstand test, or to have excessive leakage current during the dielectric test [Reference 4].

MSU: main step-up [transformer]

NEI: Nuclear Energy Institute

NPRDS: Nuclear Plant Reliability Data System

NRC: Nuclear Regulatory Commission

NRR: Nuclear Reactor Regulation (Office of)

OLRP: Oconee License Renewal Project

ONS: Oconee Nuclear Station

PB: pressure boundary

PCB: power circuit breaker

PE: polyethylene (cable insulation or jacket material)

Penstock: a gate or sluice used in controlling the flow of water

PIP: problem investigation process (station corrective action process, also refers to an item entered into the corrective action process)

polyamide: nylon

potential aging effect: a possible net change in component characteristics (due to specific processes that gradually change characteristics of a component with time or use). “Possible” as used here is defined by operating experience.

property: any trait or attribute proper to a thing; characteristic quality, peculiarity; specifically, any of the principal characteristics of a substance, especially as determined by the senses or by its effect on another substance *[*the *properties* of a chemical compound*]*; ***—Synonym:*** QUALITY [Reference 5]

PVC: polyvinyl chloride (cable insulation or jacket material)

PVF: polyvinyl fluoride (cable insulation or jacket material)

quality: any of the features that make something what it is; characteristic element; attribute; refers to a characteristic (physical or nonphysical, individual or typical) that constitutes the basic nature of a thing or is one of its distinguishing features; ***—Synonym:*** PROPERTY applies to any quality that belongs to a thing by reason of the essential nature of the thing *[*elasticity is a *property* of rubber*]* [Reference 5]

RB: Reactor Building

RCP: reactor coolant pump

RAI: request for additional information

RTD: resistance-temperature detector

RTV: room temperature vulcanizing

SBO: station blackout

SCEW: system component evaluation worksheet

self-heating: generation of heat during operation of electrical devices sufficient to raise the device temperature above ambient temperature [Reference 6, Glossary].

service conditions: actual surrounding physical states or influences that can affect a component during its service life. This includes both environmental conditions and, if applicable, component self-heating temperature rise.

SOC: Statement of Considerations, included in the Federal Register notice for the license renewal rule

SR: silicone rubber (cable insulation or jacket material)

WD-SRP-LR: Standard Review Plan for the Review of License Renewal Applications for Nuclear Power Plants

SSF: Standby Shutdown Facility

stressor: agent or stimulus that stems from pre-service and service conditions and can produce immediate or aging degradation of a component (e.g., heat, radiation) [Reference 7].

T_{75} Induction Period: The time for 75% of failures to occur. Induction Period pertains to the depletion of oxygen in an organic material. A short-hand version can be obtained from DOE Cable AMG [Reference 8, page 5-31]: a means of evaluating aging by measuring the period of time before a small sample of insulation experiences rapid oxidation when subjected to a continuous elevated temperature in an oxygen environment.

TLAA: time limited aging analysis

UFSAR: Updated Final Safety Analysis Report

WMS: Work Management System

Vulkene: General Electric trade name for cross-linked polyethylene (cable insulation or jacket material)

XLP: cross-linked polyethylene (cable insulation or jacket material)

XLPE: cross-linked polyethylene (cable insulation or jacket material)

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PART 2
OCONEE ELECTRICAL COMPONENT TIME-LIMITED AGING ANALYSES FOR LICENSE RENEWAL

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PART 1
OCONEE ELECTRICAL COMPONENT INTEGRATED PLANT ASSESSMENT FOR LICENSE RENEWAL

1 ELECTRICAL COMPONENT IPA METHODOLOGY

The basic philosophy used in the electrical component IPA process is that all plant electrical components are included in the review unless they are specifically scoped-out or screened-out. The methodology meets the requirements of §54 (for text see Table B-1) and the guidance provided in the statement of considerations (SOC), which was published with the final rule [Reference 1], and is generally consistent with the guidance provided in NEI 95-10 Rev. 0 [Reference 9]. The process followed is detailed in Figure 1-1.

1.1 Identification of all Electrical Component Commodity Groups Installed at Oconee

The electrical component IPA starts with all Oconee electrical components organized into electrical component commodity groups. The method used to identify all electrical components started with a review of industry license renewal component lists (i.e., §54.21(a)(1)(i) and NEI 95-10 Rev. 0 Appendix B) and a review of Oconee electrical system drawings. The composite list was reviewed by electrical power and I&C experts at Duke's general offices and at Oconee and was reviewed by individuals in an industry license renewal electrical peer group. This iterative process included multiple reviews by many individuals. Using Oconee and industry information along with reviews by electrical experts and industry peers provides reasonable assurance that the list of electrical components is complete and accurate.

In conjunction with the identification of electrical component commodity groups, the electrical component commodity group intended functions are identified. The intended functions are determined using Oconee, industry and regulatory reference materials along with expert reviews and were included in the same iterative review process.

Using the process gives reasonable assurance that all electrical component commodity groups installed at Oconee are identified and that the intended functions identified are correct.

The electrical component commodity groups installed at Oconee are determined in Chapter 2.

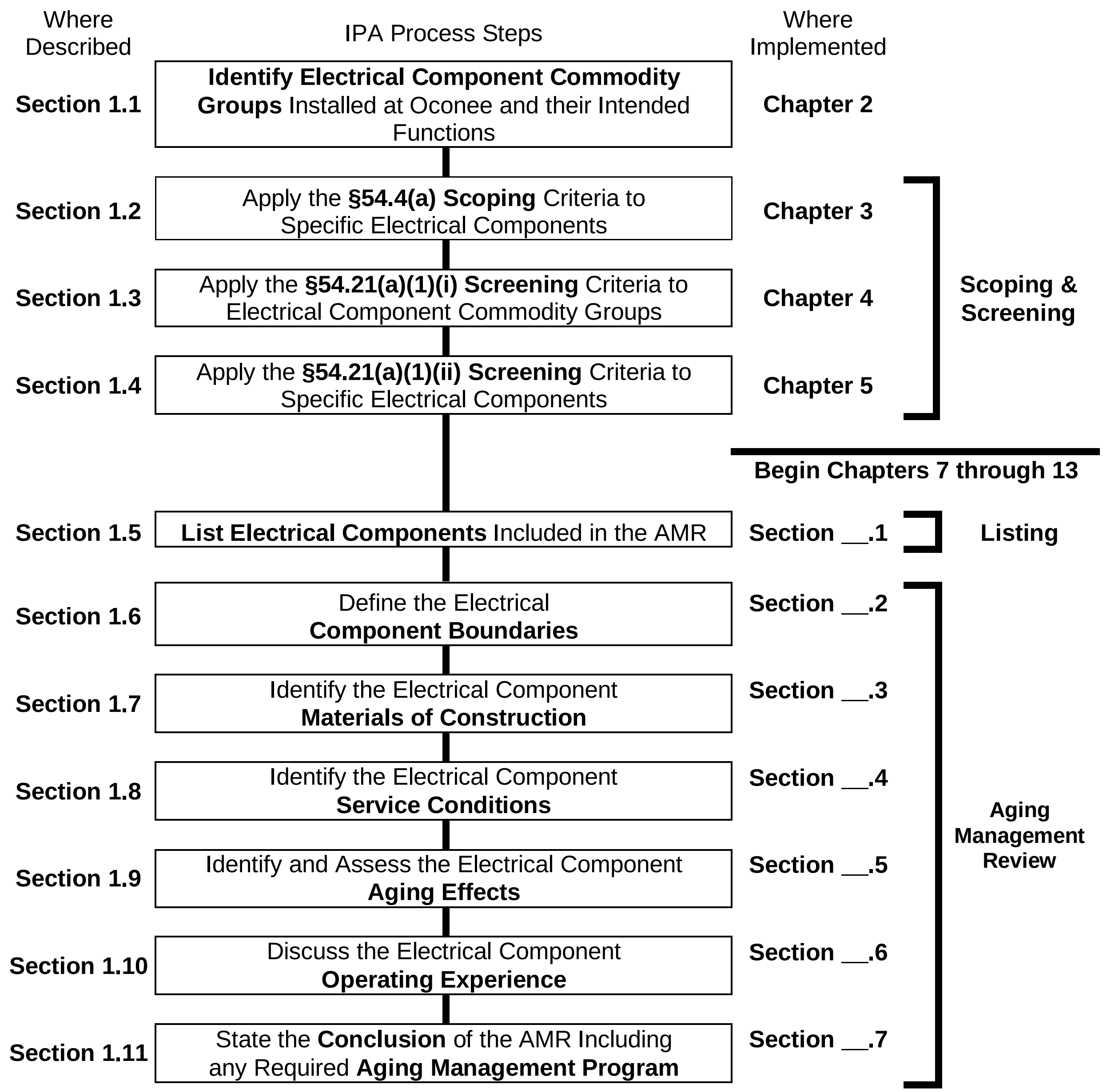

Figure 1-1
Oconee Electrical IPA Process Flow Chart

1.2 Application of the §54.4(a) Scoping Criteria to Specific Electrical Components

The basic philosophy used in the electrical component IPA process is that all plant electrical components are included in the review unless they are specifically scoped-out or screened-out. The §54.4(a) scoping criteria is applied only to specific electrical components that are scoped-out. This is in contrast to the approach of applying the criteria to all electrical components to determine those that are scoped in. The only electrical components to which the §54.4(a) criteria are applied are those electrical components that are scoped-out in Chapter 3.

To scope out electrical components, the following steps are performed:

(1) Identify the functions performed by the electrical components.

The functions performed by an electrical component are identified using several information sources such as the UFSAR [Reference 10], design basis documents and interviews with system and component experts.

(2) Compare the functions performed by the electrical components to the criteria of §54.4(a).

Electrical components are scoped-out when it is demonstrated by comparison that the functions a component performs do not meet the criteria of §54.4(a).

Electrical System Identification and Scoping

Electrical "systems" are not identified or scoped. System scoping is not required by §54.21(a)(1). The requirement is to identify and list structures and components subject to an AMR. Whether dividing the electrical portions of the plant by systems or by some other means, the objective is to ensure that no in-scope electrical components are excluded from the review. Including all plant electrical components in the review unless they are specifically scoped-out by comparing their functions to the §54.4(a) criteria ensures that all electrical components within scope are included in the review.

Including an Encompassing Group of Electrical Components in the Review

All plant electrical components are either scoped-out or are included in a broader scope of review as part of an encompassing group. An encompassing group of electrical components is a defined group that includes both electrical components that meet the §54.4(a) scoping criteria and electrical components that do not meet the §54.4(a) scoping criteria. Regarding the identification of an encompassing group of components, the statement of considerations (SOC) for 10 CFR 54 [Reference 1] states:

> **SOC to 10 CFR Part 54, Section III.f.(ii)**
>
> *A licensee has the flexibility to determine the set of structures and components for which an aging management review is performed, provided that this set encompasses the structures and components for which the Commission has determined an aging management review is required for the period of extended operation. Therefore, a licensee's aging management review must include structures and components --*
>
> *(1) That were not subject to replacement based on a qualified life or a specified time period; and*
>
> *(2) That perform an intended function (§54.4) without moving parts or without a change in configuration or properties.*

> *In establishing this flexibility, the Commission recognizes that licensees may find it preferable to not take maximum advantage of the Commission's generic conclusion regarding structures and components that do not require an aging management review, and may undertake a broader scope of review than is minimally required. For example, a licensee may desire to review all 'passive' structures and components. This set of structures and components would be acceptable because it includes 'long-lived' as well as periodically replaced structures and components and, therefore,* <u>*encompasses*</u> *all structures and components that would be identified through criteria (1) and (2) above.* (emphasis added)

Identifying and including an encompassing group of components in the scope of review is an acceptable option.

Consideration of Hypothetical Failures

Hypothetical failures are not required to be considered in the application of the §54.4(a)(2) criteria. Guidance for the application of the criteria of §54.4(a)(2) is provided in Section III.c.(iii) of the SOC accompanying the issuance of 10 CFR 54 [Reference 1] and is provided below.

> **SOC to 10 CFR Part 54, Section III.c.(iii)**
>
> *Pre-application rule implementation has indicated that the description of systems, structures, and components subject to review for license renewal could be broadly interpreted and result in an unnecessary expansion of the review. To limit this possibility for the scoping category relating to nonsafety-related systems, structures, and components, the Commission intends this nonsafety-related category (§54.4(a)(2)) to apply to systems, structures, and components whose failure would prevent the accomplishment of an intended function of a safety-related system, structure, and component. An applicant for license renewal should rely on the plant's CLB, actual plant-specific experience, industry-wide operating experience, as appropriate, and existing engineering evaluations to determine those nonsafety-related systems, structures, and components that are the initial focus of the license renewal review. Consideration of hypothetical failures that could result from system interdependencies that are not part of the CLB and that have not been previously experienced is not required.*

Using the criteria stated in the SOC to identify hypothetical failures is a valid approach and eliminating hypothetical failures from consideration in the scoping determination is justified, per the SOC guidance.

Validation of the Scoping Results

The Oconee Safety-Related Designation Clarification (OSRDC) project clarified the Oconee QA Condition 1 licensing basis and clarified the Oconee licensing basis with respect to design basis event mitigation requirements. Further details of the OSRDC project are contained in the Response to RAI 2.2-6 [Reference 11, Attachment 2]. A review of the OSRDC results was performed to identify all structures that contain electrical components that satisfy the criteria contained in §§54.4(a)(1) and (a)(2) [Reference 12]. The results of this review are used to validate the electrical components that are scoped-out. To validate the electrical component scoping, the structures that contain the electrical components that are scoped-out are compared to the list of structures that contain electrical components that satisfy the criteria contained in §§54.4(a)(1) and (a)(2). All of the scoped-out electrical components are contained in structures, which were determined not to contain any electrical components that satisfy the criteria contained in §§54.4(a)(1) and (a)(2). This validates that none of the electrical components that are scoped-out meet the criteria of §§54.4(a)(1) and (a)(2).

The application of the §54.4(a) scoping criteria is performed in Chapter 3.

1.3 Application of §54.21(a)(1)(i) Screening Criteria to Electrical Component Commodity Groups

The basic philosophy used in the electrical component IPA process is that all plant electrical components are included in the review unless they are specifically scoped-out or screened-out. Following the examples provided in §54.21(a)(1)(i), NEI 95-10 Rev. 0 [Reference 9, Appendix B], the Working Draft Standard Review Plan for License Renewal (WD-SRP-LR) [Reference 13, Table 2.2-2], the September 19, 1997 NRC letter to NEI [Reference 14] and April 27, 1999 NRC letter to NEI [Reference 15], the §54.21(a)(1)(i) screening criteria are applied to electrical component commodity groups. These reference documents provide the results of the application of the §54.21(a)(1)(i) screening criteria to most electrical component commodity groups. Most of these documented §54.21(a)(1)(i) screening determinations are credited without further review. Duke performed independent §54.21(a)(1)(i) screening determinations where Duke does not agree with the published determination and where no determination for a commodity group is documented.

The §54.21(a)(1)(i) screening determinations performed by Duke use as their basis the examples provided in the license renewal rule (i.e., §54.21(a)(1)(i)). These examples set the precedent for the kinds of functions that must be considered and the kinds of functions that are excluded under these criteria. Using this process gives reasonable assurance that a valid §54.21(a)(1)(i) screening determination is made for each electrical component commodity group.

The application of §54.21(a)(1)(i) criteria is performed in Chapter 4).

1.4 Application of the §54.21(a)(1)(ii) Screening Criteria to Specific Electrical Components

The basic philosophy used in the electrical component IPA process is that all plant electrical components are included in the review unless they are specifically scoped-out or screened-out. The §54.21(a)(1)(ii) screening criteria is applied only to specific electrical components that are screened-out. This is in contrast to the approach of applying the criteria to all electrical components to determine those that are screened-in. The only electrical components to which the §54.21(a)(1)(ii) criteria are applied are those electrical components that are screened-out in Chapter 5.

Screening out electrical components via the §54.21(a)(1)(ii) screening criteria is performed by applying the criteria stated in §54.21(a)(1)(ii) to the electrical components and by applying the associated guidance and criteria provided in Section III.f.(i)(b) of the statement of considerations (SOC) for 10 CFR 54 [Reference 1] to the electrical components. Using this process gives reasonable assurance that the §54.21(a)(1)(ii) screening determinations are valid.

Components that are Replaced Based on a Qualified Life

The criteria in §54.21(a)(1)(ii) states that structures and components subject to an aging management review shall encompass those structures and components, "That are not subject to replacement based on a qualified life…."

An interpretation of the rule has been proffered that components which are replaced based on a qualified life that is 40 years or greater can not be excluded based on the criteria of §54.21(a)(1)(ii). This interpretation can be found in Section 4.1.2 of NEI 95-10 Rev. 0 [Reference 9], but no basis for this interpretation is offered. Excluding components that are replaced based on a qualified life from the aging management review is specifically discussed in the SOC. Upon searching the guidance provided in the SOC regarding the exclusion of components that are replaced based on a qualified life, the basis for this interpretation is absent. The SOC sections that provide guidance [Reference 1, 60 FR 22478] are repeated below.

SOC to 10 CFR 54, Section III.f.(i)(b), "Long-lived" structures and components

The Commission recognizes that, as a general matter, the effects of aging on a structure or component are cumulative throughout its service life. One way to effectively mitigate these effects is to replace that structure or component, either (i) on a specified interval based upon the qualified life of the structure or component or (ii) periodically in accordance with a specified time period to prevent performance degradations leading to loss of intended function during the period of operation.

Where a structure or component is replaced based upon a qualified life (appropriately determined), it follows that the replaced structure or component will not experience detrimental effects of aging sufficient to preclude its intended function. This is because the purpose of qualification of the life of a structure or component is to determine the time period for which the intended function of that structure or component can be reasonably assured.

Where a structure or component is replaced periodically in accordance with a specified time period, the regulatory process will ensure that degraded performance of the structure or component experienced during the replacement interval will be adequately addressed and the established replacing interval will be appropriate. Thus, there is a high likelihood that the detrimental effects of aging will not accumulate during the subsequent period such that there is a loss of intended function.

In sum, a structure or component that is not replaced either (i) on a specified interval based upon the qualified life of the structure or component or (ii) periodically in accordance with a specified time period, is deemed by §54.21(a)(1)(ii) of this rule to be "long-lived," and therefore subject to the §54.21(a)(3) aging management review.

Unlike the rule regarding time-limited aging analyses (TLAAs), which specifically states that they "Involve time-limited assumptions *defined by the current operating term, for example, 40* *years,*” the criteria in §54.21(a)(1)(ii) and the SOC guidance make no such reference related to components that are replaced based on a qualified life.

Oconee screened-out electrical components that are replaced based on an appropriately determined qualified life via the criteria of §54.21(a)(1)(ii). This position is in agreement with the SOC guidance on the application of the “long-lived” criteria.

1.5 List Electrical Components Included in the AMR

The basic philosophy used in the electrical component IPA process is that all plant electrical components are included in the review unless they are specifically scoped-out or screened-out. The list of components required by §54.21(a)(1) follows this philosophy and is the culmination of the scoping and screening. Therefore, most component lists are of an encompassing group of components, which include all components subject to an AMR in addition to components that do not meet some of the scoping or screening criteria.

Each list consists of defined groups of electrical components. Groups of electrical components are identified because either the defined electrical components are not uniquely identified (e.g., individual insulators or strings of insulators have no individual identification number) or the list of uniquely identified components would contain so many entries that the detailed list would not provide any benefit (e.g., insulated cables). The list, in either case, is generated with the intention of being descriptive enough for identification of each component within the group and being meaningful and useful in the remaining steps of the electrical AMR.

The lists of insulators, switchyard bus and transmission conductors consists of a description of areas where specific groups of these components are located. The lists of isolated-phase bus, nonsegregated-phase bus and segregated-phase bus consists of a description of a group of bus sections along with the plant structures and areas where they are installed.

Insulated cables and connections are listed based on the primary insulation materials and relate the insulation materials to specific applications. In the case of insulated cable connections, it is not possible to identify all the various brands, models or materials of connections installed in the plant. In this case, specific types of connections (brands, models, or materials) are identified that, with reasonable assurance, are used at the plant and are constructed of materials that bound the material characteristics of the brands or models installed in the plant. This is justified as long as there is reasonable assurance that the actual materials of construction and their applications are matched or bounded.

Listing an encompassing group of components satisfies the listing requirement since it identifies, as a minimum, all components subject to an AMR. Identifying electrical components included in the aging management review as described in this section gives sufficient information to identify specific components for the purposes of the AMR.

An electrical component list section is provided in each electrical component commodity group chapter and the titles begin with, “List — ….”

1.6 Define the Electrical Component Boundaries

The purpose of this step in the electrical IPA process is to clearly define the component boundaries that will be used when reviewing a component; i.e., what is considered part of the component. The boundaries defined in this section are described in relation to neighboring components.

A component boundary section is provided in each electrical component commodity group chapter and the titles begin with, "Component Boundaries — …."

1.7 Identify the Electrical Component Materials of Construction

The purpose of this step is to identify the materials used in the construction of the electrical component being reviewed. It is important to know the materials of construction so that these materials can be matched with the service conditions to which they are exposed. Knowing both materials and service conditions gives the basis for identifying applicable aging effects. As it is not always possible to determine all materials or the exact materials of construction, the intent is to have reasonable assurance that all materials or materials with bounding properties are identified.

A materials section is provided in each electrical component commodity group chapter and the titles begin with, "Materials — …."

1.8 Identify the Electrical Component Service Conditions

The purpose of this step in the electrical IPA process is to identify the service conditions to which the electrical components are exposed. Service conditions are the actual surrounding physical states or influences that can affect a component during its service life. Service conditions include both environmental conditions (i.e., ambient physical states surrounding a component) and, if applicable, component self-heating temperature rise (generation of heat by electrical components during operation).

Many electrical component commodity groups are installed in common areas and are exposed to the same environmental conditions. Common environmental condition information needed for all commodity groups is located in Appendix A.

A service conditions section is provided in each electrical component commodity group chapter and the titles begin with, "Service Conditions — …."

1.9 Identify & Assess the Electrical Component Aging Effects

The purpose of this step in the electrical IPA process is to identify the potential aging effects of the electrical component materials, to assess them with respect to their service conditions and to determine if there are applicable aging effects for the component in its installed location.

An aging effects section is provided in each electrical component commodity group chapter and the titles begin with, “Aging Effects — ….”

1.10 Discuss the Electrical Component Operating Experience

The purpose of this step in the electrical IPA process is to review applicable NRC generic communications along with industry and Oconee operating experience in order to validate the applicable aging effects. This step involves a review of industry sources of problem data such as that provided in the Nuclear Plant Reliability Data System (NPRDS) database, Licensee Event Reports (LER), NRC generic communications. Oconee operating experience includes information from available Duke and Oconee sources such as the Problem Investigation Process (PIP) database and knowledgeable Duke personnel. This data search is not meant to be all-inclusive but is intended to provide reasonable assurance that all applicable aging effects have been identified.

An operating experience section is provided in each electrical component commodity group chapter and the titles begin with, “Operating Experience — ….”

1.11 State the Conclusion of the AMR Including any Required Aging Management

The purpose of this step in the electrical IPA process is to clearly state the conclusion of the AMR. This conclusion is directly related to the requirement of §54.21(a) to demonstrate that the aging effects of the electrical components included in the AMR will be adequately managed so that their intended functions will be maintained consistent with the CLB for the period of extended operation. Where no aging management is required for the component intended functions to be maintained this is simply stated. Where an aging management program is required to maintain the component intended function this section contains a description of the aging management program.

A conclusion section is provided in each electrical component commodity group chapter and the titles begin with, “AMR Conclusion — ….”.

2
IDENTIFICATION OF PLANT ELECTRICAL COMPONENT COMMODITY GROUPS AND THEIR INTENDED FUNCTIONS

All plant electrical components installed at Oconee are organized into electrical component commodity groups for the purposes of scoping, screening and the aging management review. The process followed to identify plant electrical component commodity groups is:

a) List electrical component commodity groups identified in §54.21(a)(1)(i) and NEI 95-10 Rev. 0 Appendix B (which was copied into the Table 2.2-2 of the September 1997 Working Draft of the *Standard Review Plan for the Review of License Renewal Applications for Nuclear Plants* (WD-SRP-LR) [Reference 13]).

b) Review station documents such as electrical one-line and three-line diagrams and the Oconee *Quality Standards Manual* [Reference 16] for additional electrical component commodity groups.

c) Identify the intended functions of electrical component commodity groups from industry references such as an IEEE technical dictionary [Reference 17] and the glossary of an instrumentation text [Reference 18]; add these to the list of electrical component commodity groups.

d) Have Duke electrical experts familiar with the Oconee electrical systems review the list for correctness and completeness [References 19 and 20].

e) Have electrical personnel from other utilities familiar with license renewal issues review the list, for correctness and completeness [Reference 21].

The steps identified were performed several times in an iterative process. The expert reviews included the identification of electrical components as well as their combination into commodity groups. The electrical component commodity groups identified are shown in the following table.

Table 2-1
Electrical Component Commodity Groups Installed at Oconee

Electrical Component Commodity Groups			
Alarm Units	Fuses	Meters	Solenoid Operators
Analyzers	Generators	Motor Control Centers	Solid-State Devices
Annunciators	Heat Tracing	Motors	Surge Arresters
Batteries	Heaters	Nonsegregated-Phase Bus	Switches
Chargers	Indicators	Power Distribution Panels	Switchgear
Circuit Breakers	Insulated Cables and Connections	Power Supplies	Switchyard Bus
Converters		Radiation Monitors	Thermocouples
Communication Equipment	Insulators	Recorders	Transducers
Electrical Controls and Panel Internal Component Assemblies	Inverters	Regulators	Transformers
	Isolated-Phase Bus	Relays	Transmission Conductors
	Isolators	RTDs	Transmitters
Electrical Penetration Assemblies	Light Bulbs	Segregated-Phase Bus	Uninsulated Ground Conductors
	Load Centers	Sensors	
Elements	Loop Controllers	Signal Conditioners	

As indicated in step c) above, electrical component intended functions were also identified during the process of identifying all electrical component commodity groups and received the same iterative reviews.

Electrical component commodity groups with the same intended functions are grouped for the purposes of the §54.21(a)(1)(i) scoping determination. In addition, when one of the reference documents identifies a specific type of component, the commodity group to which the component belongs is given the same §54.21(a)(1)(i) screening determination. For example, since pressure indicators and water level indicators are identified in §54.21(a)(1)(i) as being excluded from an AMR, the commodity group "indicators" is excluded from an AMR. The basis for this is that all indicators have the same intended function, which is to indicate or represent the value of a parameter being measured. What is being indicated—be it pressure, water level or some other parameter—does not change the way the indicator performs its intended function. Other specific examples where larger commodity groups are chosen are generators for diesel generators, meters for ammeter, transducer for watt transducer, light bulbs for indicating lights and solid-state devices for circuit boards and transistors. The result of the process is shown in Table 2-2. The columns of Table 2-2 are explained below:

- **The ELECTRICAL COMPONENT COMMODITY GROUPS column** identifies the name given to the electrical component commodity group and in many cases is followed by examples of electrical components in the commodity group. The electrical component examples include most, if not all, of those listed in WD-SRP-LR Table 2.2-2 along with others identified during the component listing process described in Section 2. The examples are not meant to include every variation of a particular electrical component commodity that is included in the commodity group, but are samples to aid understanding the commodity group.

- **The INTENDED FUNCTIONS column** identifies the intended functions applicable to the components within each commodity group.
- **The WD-SRP-LR ITEM NUMBERS column** provides the item numbers of components listed in WD-SRP-LR Table 2.2-2 that have been included within each commodity group. This information was included as a convenience to be used as a cross-reference to WD-SRP-LR Table 2.2-2. These item numbers are the same as those in NEI 95-10 Appendix B. The item numbers of all electrical components combined into a commodity group are listed in this column. When "N/A" appears in the right column, it indicates that the commodity group is not listed or represented in WD-SRP-LR Table 2.2-2.

Table 2-2
Electrical Component Commodity Group Intended Functions

Electrical Component Commodity Groups	Intended Functions	WD-SRP-LR Item Number
Alarm Units (e.g., fire detection devices)	To sense a parameter and provide an output at a predetermined (threshold) level.	104
Analyzers (e.g., gas analyzer, conductivity analyzer)	To examine the item being analyzed and determine its constituent parts.	97
Annunciator (e.g., lights, buzzers, alarms)	To audibly and visually alert operators of a plant condition or occurrence.	115
Batteries	To store energy.	134
Cables and Connections, Bus **Specifically: Insulated Cables & Connections, Isolated-Phase Bus, Nonsegregated-Phase Bus, Segregated-Phase Bus, Switchyard Bus, Transmission Conductors, Uninsulated Ground Conductors** (e.g., power cable, instrument cable, control cable, communication cable, bare cable, connector, splice, terminal block, switchgear bus, load center bus, motor control center bus)	To electrically connect two sections of an electrical circuit.	141, 142
Chargers, Converters, Inverters (e.g., voltage/current converter, voltage/pneumatic converter, battery charger/inverter, motor-generator set)	To convert energy from one form into another form.	109, 110, 135
Circuit Breakers (e.g., air circuit breaker, molded case circuit breaker, oil-filled circuit breaker)	To connect or disconnect an electrical circuit in a controlled manner.	128

Electrical Component Commodity Groups	Intended Functions	WD-SRP-LR Item Number
Communication Equipment (e.g., telephone, video or audio recording or playback equipment, intercom, computer terminal, electronic messaging, radios, transmission line traps and other power-line carrier equipment)	To permit the interchange of information.	N/A
Electrical Controls and Panel Internal Component Assemblies (includes internal devices such as, but not limited to, switches, indicating lights, annunciators, recorders, indicators, meters, relays, fuses, fuse blocks, terminal blocks, hook-up wire)	To provide an operator/plant equipment and system control and monitoring interface.	138
Electrical Penetration Assemblies	To electrically connect two sections of an electrical circuit through the containment wall while maintaining containment integrity.	16
Elements, RTDs, Sensors, Thermocouples, Transducers (e.g., temperature sensor, conductivity element, flow element, thermocouple, RTD, vibration probe, watt transducer, amp transducer, frequency transducer, power factor transducer, speed transducer, var transducer, vibration transducer, voltage transducer)	To convert a measured physical parameter into a proportional electrical output or parameter change.	86, 88, 93, 120, 121
Fuses	To disconnect an electrical circuit at a predetermined current and duration.	N/A
Generators, Motors (e.g., diesel generator, steam turbine generator, combustion turbine generator, fan motor, pump motor, valve motor, air compressor motor)	To convert mechanical energy into electrical energy or electrical energy into mechanical energy.	56, 65, 66, 136
Heat Tracing, Heaters	To generate heat.	139, 140
Indicators (e.g., analog indicator, digital indicator, LED bar graph indicator, LCD indicator, temperature indicator, flow indicator, differential pressure indicator, pressure indicator, level indicator, speed indicator)	To indicate or represent the value of a parameter being measured.	76, 80, 102, 105, 117, 118
Insulators [separate, high voltage equipment] (e.g., porcelain insulator)	To insulate and support an electrical conductor.	N/A
Isolators (e.g., transformer isolator, optical isolator, isolation relay, isolating transfer diode)	To isolate part of an electrical circuit from the undesired influence of other parts of the circuit.	112
Light Bulbs (e.g., incandescent light bulb, fluorescent light bulb, indicating light)	To illuminate.	165

Electrical Component Commodity Groups	Intended Functions	WD-SRP-LR Item Number
Loop Controllers (e.g., programmable logic controller, single loop digital controller, process controller {pressure, speed, temperature}, manual loader, selector station, hand/auto station, auto/manual station)	To measure the value of a variable and correct or limit deviation from a reference value.	101, 103, 107, 111, 119
Meters (e.g., ammeter, volt meter, frequency meter, var meter, watt meter, power factor meter, watt-hour meter)	To measure (and indicate) the value of a parameter.	116
Power Supplies	To convert input power to a prescribed voltage.	108
Radiation Monitors (e.g., area radiation monitor, process radiation monitor)	To measure the amount of radiation.	95
Recorders (e.g., chart recorder, digital recorder, events recorder)	To record input data for later reference or retrieval.	114
Regulators (e.g., voltage regulator)	To vary or prevent variation in a desired characteristic.	N/A
Relays (e.g., protective relay, control/logic relay, auxiliary relay)	To open and close electrical contacts in a specified manner based on electrical, mechanical, thermal or other type of input.	129, 130
Signal Conditioners	To maintain a signal within specified parameters.	113
Solenoid Operators	To move an armature in a reciprocating motion.	75
Solid-State Devices (e.g., transistor, circuit board, computer)	To control current using electric or magnetic phenomena in solids.	127
Surge Arresters [separate, high voltage equipment] (e.g., lightning arrester, surge suppresser, surge capacitor, protective capacitor)	To limits surge voltages or currents on an electrical circuit.	N/A
Switches (e.g., differential pressure indicating switch, differential pressure switch, pressure indicator switch, pressure switch, flow switch, conductivity switch, level indicating switch, temperature indicating switch, temperature switch, moisture switch, position switch, vibration switch, level switch, control switch, automatic transfer switch, manual transfer switch, manual disconnect switch, current switch, limit switch, knife switch)	To open, close or change the connections of an electrical circuit.	77, 78, 81, 82, 84, 87, 89, 91, 92, 98, 99, 100, 106, 131, 132, 133

Electrical Component Commodity Groups	Intended Functions	WD-SRP-LR Item Number
Switchgear, Load Centers, Motor Control Centers, Power Distribution Panels (includes internal component assemblies such as, but not limited to, busses, breakers, indicating lights, transformers, relays, meters, switches, fuses, fuse blocks, terminal blocks, hook-up wire, insulators)	To provide the means in a consolidated enclosure to connect or disconnect electrical loads in a controlled manner from a common bus.	123, 124, 125, 126, 137
Transformers (e.g., large power transformer, load center transformer, small distribution transformer, instrument transformer, isolation transformer, coupling capacitor voltage transformer)	To induce a voltage in a separate electrical circuit.	122, 143, 144
Transmitters (e.g., flow transmitter level transmitter, differential pressure transmitter, static pressure transmitter)	To send (output) an electrical signal.	79, 83, 85, 90, 96

3 APPLICATION OF §54.4(a) SCOPING CRITERIA

The basic philosophy used in the electrical component IPA process is that all plant electrical components are included in the review unless they are specifically scoped-out or screened-out. The §54.4(a) scoping criteria is applied only to the following specific electrical components that are scoped-out:

- Electrical components associated with the 525kV Switchyard
- Electrical components associated with the Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines
- Electrical components associated with the Radwaste Facility
- Electrical components associated with the Oconee Retail Substation
- Uninsulated ground conductors

The basis for scoping out the electrical components identified above via the application of §54.4(a) scoping criteria is provided in the following sections.

3.1 Application of §54.4(a) Scoping Criteria to Electrical Components Associated with the 525kV Switchyard

Oconee UFSAR [Reference 10] Section 8.2.1.2 describes the 525kV Switchyard. Oconee Unit 3 generates electric power to the 525kV Switchyard. Three transmission lines connect the 525kV Switchyard to the Duke transmission grid. In addition, a 230/525kV autotransformer connects the 525kV Switchyard to the 230kV Switchyard.

The 525kV Switchyard and its associated equipment (including all other equipment operating at 525kV) do not perform or support any of the functions identified in §54.4(a)(1). The 525kV Switchyard and its associated equipment are not relied upon to remain functional during or following any design basis event. This conclusion is validated by a study of the OSRDC project results [Reference 12]. Unit 3 generates power to the 525kV Switchyard but the assured power source for Unit 3 is the Keowee Hydroelectric Station through the underground or overhead power paths. No failure of the 525kV Switchyard or its associated equipment will prevent satisfactory accomplishment of any functions identified in §54.4(a)(1). Loss of any 525kV equipment or transmission lines will not adversely affect the operation of the 230kV Switchyard or any other equipment relied upon during or following any design basis event.

The 525kV Switchyard and its associated equipment are not relied upon in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for fire protection, pressurized thermal shock, or anticipated transients without scram. The 525kV Switchyard and its associated equipment are not included in the Oconee EQ program and no credit is taken for the 525kV Switchyard or its associated equipment to address station blackout. Therefore, the 525kV Switchyard and its associated equipment are not relied upon in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for fire protection (10 CFR 50.48), environmental qualification (10 CFR 50.49), pressurized thermal shock (10 CFR 50.61), anticipated transients without scram (10 CFR 50.62), or station blackout (10 CFR 50.63).

Electrical components associated with the 525kV Switchyard do not meet the criteria of §54.4(a) and are not subject to an aging management review (AMR).

3.2 Application of §54.4(a) Scoping Criteria to Electrical Components Associated with the Jocassee, Calhoun, Oconee and Dacus 230kV Transmission Lines

The Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines serve to connect Oconee with the remainder of the Duke 230kV transmission system. The Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines are shown on the simplified one-line diagram of the Oconee 230kV Switchyard in Figure 2.6-4 of Exhibit A of the Application.

The Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines do not perform or support any of the functions identified in §54.4(a)(1). The emergency power source for the Oconee units is Keowee, which can feed power to Oconee via an underground cable or via an overhead power path through a portion of the 230kV Switchyard. When used for emergency power, the overhead power path is isolated from the remainder of the 230kV Switchyard, which also isolates overhead power path from the Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines. The Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines are not relied upon to remain functional during or following any design basis event. This conclusion is validated by a study of the OSRDC project results [Reference 12]. No failure of the Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines will prevent satisfactory accomplishment of any functions identified in §54.4(a)(1). Loss of the Jocassee, Calhoun, Oconee, or Dacus 230kV transmission lines will not adversely affect the operation of the 230kV Switchyard or any other equipment relied upon during or following any design basis event.

The Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines are not relied upon in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for fire protection, pressurized thermal shock, or anticipated transients without scram. The Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines are not included in the Oconee EQ program. Loss of all these 230kV transmission lines may enter into the initiation of a station blackout event, but, as stated in Section III, *Review Procedures*, of the September 1997 Working Draft of the Standard Review Plan for the Review of License Renewal Applications for Nuclear Power Plants:

> *"A system, structure, and component whose operation or failure is assumed to be the initiator of the event or is assumed to make the event more severe need not be identified as within scope of license renewal."*

No credit is taken for the Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines to address station blackout. Therefore, the Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines are not relied upon in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for fire protection (§50.48), environmental qualification (§50.49), pressurized thermal shock (§50.61), anticipated transients without scram (§50.62) or station blackout (§50.63).

Electrical components associated with the Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines do not meet the criteria of §54.4(a) and are not subject to an AMR.

3.3 Application of §54.4(a) Scoping Criteria to Electrical Components Associated with the Radwaste Facility

The Radwaste Facility is designed to process radioactive waste before shipment offsite and serves no function related to the generation of power or the operation of the reactor. The Radwaste Facility does not perform or support any of the functions identified in §54.4(a)(1). The Radwaste Facility is not relied upon to function during or following any design basis event. This conclusion is validated by a study of the OSRDC project results [Reference 12]. No failure of the Radwaste Facility or any Radwaste Facility equipment will prevent satisfactory accomplishment of any functions identified in §54.4(a)(1).

The Radwaste Facility is not relied upon in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for fire protection, pressurized thermal shock, or anticipated transients without scram. The Radwaste Facility and none of its equipment is included in the Oconee EQ program and no credit is taken for the Radwaste Facility to address station blackout. Therefore, the Radwaste Facility and its associated equipment are not relied upon in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for fire protection (10 CFR 50.48), environmental qualification (10 CFR 50.49), pressurized thermal shock (10 CFR 50.61), anticipated transients without scram (10 CFR 50.62), or station blackout (10 CFR 50.63).

Electrical components associated with the Radwaste Facility do not meet the criteria of §54.4(a) and are not subject to an AMR.

3.4 Application of §54.4(a) Scoping Criteria to Electrical Components Associated with the Oconee 44kV Retail Substation

Oconee Retail is a 44kV substation that is used to deliver retail power to the Oconee site. The power supplied from the Oconee Retail substation feeds normal site loads and does not feed any unit loads related to power generation. The Oconee Retail substation does not perform or support any of the functions identified in §54.4(a)(1). The Oconee Retail substation is not relied upon to function during or following any design basis event. This conclusion is validated by a study of the OSRDC project results [Reference 12]. No failure of the Oconee Retail substation or any Oconee Retail substation equipment will prevent satisfactory accomplishment of any functions identified in §54.4(a)(1).

The Oconee Retail substation is not relied upon in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for fire protection, pressurized thermal shock, or anticipated transients without scram. The Oconee Retail substation and none of its equipment is included in the Oconee EQ program and no credit is taken for the Oconee Retail substation to address station blackout. Therefore, the Oconee Retail substation and its associated equipment are not relied upon in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for fire protection (10 CFR 50.48), environmental qualification (10 CFR 50.49), pressurized thermal shock (10 CFR 50.61), anticipated transients without scram (10 CFR 50.62), or station blackout (10 CFR 50.63).

Electrical components associated with the Oconee 44kV Retail substation do not meet the criteria of §54.4(a) and are not subject to an AMR.

3.5 Application of §54.4(a) Scoping Criteria to Uninsulated Ground Conductors

Uninsulated ground conductors are electrical conductors (e.g., copper cable, copper bar, steel bar) that are uninsulated (bare) and are used to make ground connections for electrical equipment. Uninsulated ground conductors are connected to electrical equipment housings and electrical enclosures as well as metal structural features such as the cable tray system and building structural steel. Uninsulated ground conductors are always isolated or insulated from the electrical operating circuits. Uninsulated ground conductors enhance the capability of the electrical system to withstand electrical system disturbances (e.g., electrical faults, lightning surges) for equipment and personnel protection.

To determine if uninsulated ground conductors serve any license renewal intended functions, the §54.4 criteria is examined using the guidance provided in Section III.c.(iii) of the statement of considerations (SOC) accompanying the issuance of 10 CFR 54 [Reference 1] and NEI 95-10 Rev. 0 [Reference 9, Section 3.1]. §54.4 is quoted in Table B-1.

NEI 95-10 Rev. 0 [Reference 9, Section 3.1.1] discusses application of the criteria of §54.4(a)(1). Uninsulated ground conductors are always isolated or insulated from the electrical operating circuits. As they are not part of the electrical operating circuits, uninsulated ground conductors do not perform any functions that meet the criteria of §54.4(a)(1). Uninsulated ground conductors are not relied upon to remain functional during or following any design basis event.

Guidance for the application of the criteria of §54.4(a)(2) is provided in Section III.c.(iii) of the SOC to 10 CFR Part 54 and is provided below.

SOC to 10 CFR Part 54, Section III.c.(iii)

Pre-application rule implementation has indicated that the description of systems, structures, and components subject to review for license renewal could be broadly interpreted and result in an unnecessary expansion of the review. To limit this possibility for the scoping category relating to nonsafety-related systems, structures, and components, the Commission intends this nonsafety-related category (§54.4(a)(2)) to apply to systems, structures, and components whose failure would prevent the accomplishment of an intended function of a safety-related system, structure, and component. An applicant for license renewal should rely on the plant's CLB, actual plant-specific experience, industry-wide operating experience, as appropriate, and existing engineering evaluations to determine those nonsafety-related systems, structures, and components that are the initial focus of the license renewal review. Consideration of hypothetical failures that could result from system interdependencies that are not part of the CLB and that have not been previously experienced is not required.

This SOC guidance regarding hypothetical failures is applied to uninsulated ground conductors. No discussion of uninsulated ground conductors is presented in the Oconee UFSAR and no failures of uninsulated ground conductors are identified in the single failure analysis tables in Chapter 8 of the Oconee UFSAR. Failures of uninsulated ground conductors, or other parts of the plant grounding system are not included in the Oconee Probabilistic Risk Assessment (PRA) or the Keowee PRA [Reference 22]. There has not been an age-related failure of an uninsulated ground conductor at Oconee. Additionally, a search of the NPRDS and LER databases found no failures of uninsulated ground conductors. Uninsulated ground conductor failures meet the hypothetical failure attributes as discussed in the SOC. Uninsulated ground conductor failures are hypothetical and, per the SOC guidance, are not required to be considered. Therefore, there are no failures of uninsulated ground conductors, which are required to be considered, that could prevent satisfactory accomplishment of any of the functions identified in §54.4(a)(1)(i), (ii) or (iii).

Uninsulated ground conductors are not relied upon in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for fire protection. Uninsulated ground conductors are not included in the Oconee EQ Program. Uninsulated ground conductors have no relationship to pressurized thermal shock. No credit is taken for uninsulated ground conductors to address anticipated transients without scram or to address station blackout. Therefore, uninsulated ground conductors are not relied on in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for fire protection (10 CFR 50.48), environmental qualification (10 CFR 50.49), pressurized thermal shock (10 CFR 50.61), anticipated transients without scram (10 CFR 50.62), or station blackout (10 CFR 50.63).

Uninsulated ground conductors do not meet the criteria of §54.4(a) and are not subject to an AMR.

3.6 Results — Application of §54.4(a) Scoping Criteria

Electrical components associated with the 525kV Switchyard, the Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines, the Radwaste Facility and the Oconee 44kV Retail substation do not meet the criteria of §54.4(a) and are not subject to an AMR. Uninsulated ground conductors do not meet the criteria of §54.4(a) and are not subject to an AMR.

4
APPLICATION OF §54.21(a)(1)(i) SCREENING CRITERIA

This chapter provides the application of §54.21(a)(1)(ii) screening criteria to all plant electrical component commodity groups installed at Oconee. The electrical component commodity group §54.21(a)(1)(i) screening determinations are identified as either Yes or No as defined below:

- "**Yes**" indicates that the components in the commodity group meet the §54.21(a)(1)(i) screening criteria (i.e., the components in the commodity group perform their intended function without moving parts or without a change in configuration or properties). The electrical components in these commodity groups are carried forward in the electrical IPA for further review.
- "**No**" indicates that the components in the commodity group do not meet the §54.21(a)(1)(i) screening criteria (i.e., the components in the commodity group ***do not*** perform their intended function without moving parts or without a change in configuration or properties). The electrical components in these commodity groups are not subject to an AMR and receive no further review in the electrical IPA.

Duke credits some §54.21(a)(1)(i) screening determinations documented in industry references and Duke documents the basis for the remaining electrical component commodity group §54.21(a)(1)(i) screening determinations in this specification. These are discussed in the following separate sections.

4.1 Industry Credited Electrical Component Commodity Group §54.21(a)(1)(i) Screening Determinations

Currently three industry documents provide §54.21(a)(1)(i) screening determinations for electrical components. These documents are:

- 10 CFR 54.21(a)(1)(i)
- WD-SRP-LR Table 2.2-2 [Reference 13] (which was copied from NEI 95-10 Rev. 0 Appendix B [Reference 9])
- September 19, 1997, NRC letter to NEI [Reference 14]
- April 27, 1999, NRC letter to NEI [Reference 15]

These documents provide sufficient basis for the §54.21(a)(1)(i) screening determinations they document.

A Note Regarding RTDs and Thermocouples:
A telephone conference with the NRC staff on January 7, 1999 clarified an inconsistency within NEI 95-10 Rev. 0 Appendix B concerning thermocouples, RTDs and temperature sensors. Temperature sensors are identified in NEI 95-10 Rev. 0 Appendix B (Item #93) as "Yes (PB only)" which means that the only "passive" intended function of a temperature sensor is that of a mechanical system pressure boundary. Thermocouples and RTDs are essentially types of temperature sensors. Thermocouples and RTDs are identified in NEI 95-10 Rev. 0 Appendix B (Item #121) as "Yes." The consensus reached during the staff telephone conference is that "(PB only)" should be added to the "passive" identification for thermocouples and RTDs and that the electrical intended functions of thermocouples and RTDs are "active" and do not meet the criteria of §54.21(a)(1)(i). Mechanical pressure boundary intended functions are addressed, as appropriate, in the mechanical component aging management review specification for license renewal [Reference 23] and has no bearing on the way the electrical intended function of the element or sensor is performed. Duke agrees with this determination and will pursue incorporating this change into the next revision to NEI 95-10. This clarification is documented in the response to RAIs 2.6-6 and 2.6-7 [see Reference 11, Attachment 3]. Therefore, for the purposes of this review, RTDs and thermocouples are considered to be included in the "sensor" commodity group in NEI 95-10 Rev. 0 Appendix B and are excluded from an AMR.

The following table identifies the reference document for each electrical component commodity group §54.21(a)(1)(i) screening determination credited by Duke:

Table 4-1
Industry Reference Electrical Component Commodity Group
§54.21(a)(1)(i) Screening Determinations Credited by Duke

Reference Document	§54.21(a)(1)(i) Criteria are Met	Electrical Component Commodity Groups
§54.21(a)(1)(i)	Yes	Electrical cables and connections (i.e., insulated cables and connections, transmission conductors, uninsulated ground conductors), electrical penetration assemblies
	No	Batteries, chargers (e.g., battery chargers), circuit boards and transistors (i.e., solid-state devices), breakers (i.e., circuit breakers), generators (e.g., diesel generators), indicators (e.g., pressure indicators, water level indicators), inverters (e.g., power inverters), motors, power supplies, relays, switches, switchgear, transmitters (e.g., pressure transmitters)
WD-SRP-LR Table 2.2-2 (copied from NEI 95-10 Rev. 0 Appendix B)	No	alarm units, analyzers, annunciators, converters (e.g., voltage/current, voltage/pneumatic), electrical controls and panel internal component assemblies, elements (e.g., conductivity elements, flow elements), isolators, load centers, loop controllers (e.g., differential pressure indicating controller, flow indicating controller, temperature controller, speed controller), meters (e.g., ammeter), motor control centers, power distribution panels, radiation monitors, recorders, RTDs, sensors (e.g., temperature sensors, radiation sensors), signal conditioners, solenoid operators, thermocouples, transducers (e.g., watt transducer)
September 19, 1997, NRC letter to NEI	No	heat tracing, heaters, indicating lights (i.e., light bulbs), transformers
April 27, 1999, NRC letter to NEI	No	Fuses

Duke credits and uses the §54.21(a)(1)(i) screening determinations identified in Table 4-1 above.

4.2 Duke Electrical Component Commodity Group §54.21(a)(1)(i) Screening Determinations

The three industry references do not include several electrical component commodity groups. In addition, Duke does not agree with the §54.21(a)(1)(i) screening determination for fuses that is documented in the September 19, 1997, NRC letter to NEI [Reference 14]. Duke provides the §54.21(a)(1)(i) screening determinations and their bases for these electrical component commodity groups. These electrical component commodity groups are listed in the table below.

Table 4-2
Electrical Component Commodity Group §54.21(a)(1)(i)
Screening Determinations Made by Duke

Commodity Groups
communication equipment
insulators
isolated-phase bus, nonsegregated-phase bus, segregated-phase bus, switchyard bus
regulators
surge arresters

The §54.21(a)(1)(i) screening determination and basis for each electrical component commodity group is provided below.

Communication Equipment

The intended function of communication equipment is to permit the interchange of information. This electrical component commodity group includes any number of components that are used to send or receive communication signals including such things as telephones, intercoms, video or audio recording or playback equipment, electronic messaging, radios and power-line carrier equipment including transmission line traps. These communication devices involve processes such as conversions between audible or visible energy and electrical energy, and the transmission and receiving of electrical or electromagnetic signals. These processes produce physical property changes in the equipment that are readily detectable as audible or visible energy. Therefore, communication equipment does not meet the criteria of §54.21(a)(1)(i) and is not subject to an AMR.

Insulators

The insulators addressed here are high voltage insulators that are large enough to be considered a separate piece of equipment and not a part of some larger component. The intended function of high voltage insulators is to insulate and support an electrical conductor. Insulators perform this intended function without moving parts or without a change in configuration or properties. Therefore, insulators meet the criteria of §54.21(a)(1)(i).

Isolated-Phase Bus, Nonsegregated-Phase Bus, Segregated-Phase Bus, Switchyard Bus

Isolated-phase bus, nonsegregated-phase bus, segregated-phase bus and switchyard bus perform the same intended function as electrical cables (to electrically connect two sections of an electrical circuit) and are also considered to perform this intended function without moving parts or without a change in configuration or properties. Therefore, isolated-phase bus, nonsegregated-phase bus, segregated-phase bus, switchyard bus meet the criteria of §54.21(a)(1)(i).

Regulators

The intended function of a regulator is to vary or prevent variation in a desired characteristic. The regulators addressed here are those considered to be a separate piece of equipment and not a part of a larger component. At Oconee, this group consists of voltage regulators that provide power to regulated power panelboards. These regulators are autotransformers with several different taps. The output voltage is kept constant (or within a specified range) by changing the transformer tap based on the input voltage. The tap changes are circuit configuration changes within the regulator that are performed by automatically controlled switches. This automatic switching is an electrical circuit configuration change that is directly related to the intended function of a regulator; i.e., a regulator performs its intended function by a change in configuration. This indicates that regulators *do not* perform their intended function without moving parts or without a change in configuration or properties. Therefore, regulators do not meet the criteria of §54.21(a)(1)(i) and are not subject to an AMR.

Surge Arresters

Surge arresters are devices used to limit surge voltages and currents on electrical circuits and include components such as lightning arresters, surge suppressers, surge capacitors and protective capacitors. The surge arresters addressed here include high voltage surge arresters that are large enough to be considered a separate piece of equipment and are not a part of some larger component. At Oconee, surge arresters are used in applications associated with large motors, the unit generators, large transformers and transmission lines.

Surge arresters perform their intended function through a change in state similar to a transistor, which is excluded in §54.21(a)(1)(i) from an aging management review. Surge arresters are constructed of either silicon carbide or metal oxide. These are both semiconducting materials that exhibit a very large resistance at lower (normal system) voltages and a very low resistance at high (surge) voltages. Surge arresters may also have gaps built in to help discharge the surge voltage. At normal system voltage, an arrester exhibits a very large resistance and behaves like an insulator with very little leakage current (no leakage if the design also has gaps). When a voltage surge is encountered, the resistance of the material decreases and a surge arrester behaves like a short circuit, discharging the surge to ground. After the surge passes, an arrester material reverts to its high resistance and reseals the circuit. A surge arrester uses these changes in material properties to perform its intended function in the same way that solid-state devices perform their intended function of controlling current using electric or magnetic phenomena in solids. This indicates that surge arresters *do not* perform their intended function without moving parts or without a change in configuration or properties. Therefore, surge arresters do not meet the criteria of §54.21(a)(1)(i) and are not subject to an AMR.

4.3 Results — Application of §54.21(a)(1)(i) Screening Criteria

The §54.21(a)(1)(i) screening determinations are summarized in Table 4-3. There are four columns to the left of the table, which correspond to the four documents where §54.21(a)(1)(i) screening determinations are documented—the three industry references and this specification. A shaded block under one of these columns and to the left of a component name indicates which document contains the credited §54.21(a)(1)(i) screening determination for the identified electrical component commodity group.

Legend For Table 4-3 **Reference Documents Credited for Electrical Component Commodity Group §54.21(a)(1)(i) Screening Determinations**
The shaded blocks indicate the credited reference document: (a): §54.21(a)(1)(i) [Reference 1] (b): WD-SRP-LR Table 2.2-2 [Reference 13] (c): September 19, 1997, NRC letter to NEI [Reference 14] (d): April 27, 1999, NRC letter to NEI [Reference 15] (e): Section 4.2 of this specification

Table 4-3
§54.21(a)(1)(i) Screening Determinations for

Credited Reference *(see Legend)* (a)	(b)	(c)	(d)	(e)	Oconee Electrical Component Commodity Groups	§54.21(a)(1)(i) Criteria are Met
	■				Alarm Units	No
	■				Analyzers	No
	■				Annunciators	No
■					Batteries	No
■					Chargers	No
■					Circuit Breakers	No
	■				Converters	No
				■	Communication Equipment	No
	■				Electrical Controls and Panel Internal Component Assemblies	No
■					Electrical Penetration Assemblies	Yes
	■				Elements	No
			■		Fuses	No
■					Generators	No
		■			Heat Tracing	No
		■			Heaters	No
■					Indicators	No
■					Insulated Cables and Connections	Yes
				■	Insulators	Yes
■					Inverters	No
				■	Isolated-Phase Bus	Yes
	■				Isolators	No
		■			Light Bulbs	No
	■				Load Centers	No
	■				Loop Controllers	No
	■				Meters	No
	■				Motor Control Centers	No
■					Motors	No
				■	Nonsegregated-Phase Bus	Yes

Credited Reference (see Legend) (a)	(b)	(c)	(d)	(e)	Oconee Electrical Component Commodity Groups	§54.21(a)(1)(i) Criteria are Met
	■				Power Distribution Panels	No
■					Power Supplies	No
	■				Radiation Monitors	No
	■				Recorders	No
				■	Regulators	No
■					Relays	No
	■				RTDs	No
				■	Segregated-Phase Bus	Yes
	■				Sensors	No
	■				Signal Conditioners	No
	■				Solenoid Operators	No
■					Solid-State Devices	No
				■	Surge Arresters	No
■					Switches	No
■					Switchgear	No
					Switchyard Bus	Yes
	■				Thermocouples	No
	■				Transducers	No
		■			Transformers	No
■					Transmission Conductors	Yes
■					Transmitters	No
■					Uninsulated Ground Conductors	Yes

5
APPLICATION OF 54.21 (a)(1)(ii) SCREENING CRITERIA

The basic philosophy used in the electrical component IPA process is that all plant electrical components are included in the review unless they are specifically scoped-out or screened-out. The §54.21(a)(1)(ii) screening criteria is applied only to the following specific electrical components that are screened-out:

- Electrical penetration assemblies
- Insulated cables and connections included in the Oconee environmental qualification (EQ) program

The basis for screening out the electrical components identified above via the application of §54.21(a)(1)(ii) screening criteria is provided in the following sections.

5.1 Application of §54.21(a)(1)(ii) Screening Criteria to Electrical Penetration Assemblies

All electrical penetration assemblies are included in the Oconee EQ program. The Oconee EQ Program is described in the UFSAR [Reference 10, Chapter 3.11]. Electrical penetration assemblies, as included in the EQ Program, have a qualified life, which is documented in the EQ Master List [Reference 24]. With a documented qualified life, electrical penetration assemblies do not meet the criteria of §54.21(a)(1)(ii) and are not subject to an AMR.

5.2 Application of §54.21(a)(1)(ii) Screening Criteria to Insulated Cables & Connections Included in the Oconee EQ Program

Numerous insulated cables and connections are included in the Oconee EQ Program. The Oconee EQ Program is described in the UFSAR [Reference 10] and Oconee station directives as part of the Duke Power Nuclear Policy Manual.

Insulated cables and connections included in the Oconee EQ Program have a qualified life that is documented in the Oconee Response to IE Bulletin 79-01B cable SCEW sheets (system component evaluation worksheets) and is administratively controlled by the Oconee EQ Program. Insulated cables and connections with a documented qualified life do not meet the criteria of §54.21(a)(1)(ii) and are not subject to an AMR.

5.2.1 LR Scope Vs. EQ Scope for Insulated Cables & Connections in the Reactor Buildings

To better understand which insulated cables and connections are being excluded as part of the Oconee EQ Program, the scope of the Oconee EQ Program is compared to the other license renewal scoping criteria of §54.4.

This scope comparison is focused on the Reactor Buildings. One reason for this focus is that some areas of the Reactor Buildings contain more extreme environmental conditions than other areas of the plant. Another reason is the Reactor Buildings are identified in the Oconee EQ Program as harsh environmental areas and most insulated cables and connections within §54.4 scope that are installed in the Reactor Buildings are included within the Oconee EQ Program.

EQ Program equipment is included within the scope of license renewal per §54.4(a)(3). Therefore, the purpose of this comparison is to determine which EQ insulated cables and connections installed in the Reactor Buildings are within scope under §54.4 criteria *other* than §50.49. The scope comparison is detailed in the following table.

Table 5-1
License Renewal & Environmental Qualification Scope Comparison

§54.4 – License Renewal Scope (see Table B-1)	**§50.49 - Environmental Qualification Scope (see Table B-2)**
(a) Plant systems, structures, and components within the scope of this part are --	(b) Electric equipment important to safety covered by this section is:
(1) Safety-related systems, structures, and components which are those relied upon to remain functional during and following design-basis events to ensure the following functions:	(1) Safety-related electrical equipment. (i) This equipment is that relied upon to remain functional during and following design basis events to ensure:
(i) The integrity of the reactor coolant pressure boundary;	(A) The integrity of the reactor coolant pressure boundary;
(ii) The capability to shut down the reactor and maintain it in a safe shutdown condition; or	(B) The capability to shut down the reactor and maintain it in a safe shutdown condition; and
(iii) The capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to the guidelines in §50.34(a)(1) or §100.11 of this chapter, as applicable.	(C) The capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to the guidelines in §50.34(a)(1) or §100.11 of this chapter, as applicable.
(2) All nonsafety-related systems, structures, and components whose failure could prevent satisfactory accomplishment of any of the functions identified in paragraphs (a)(1)(i), (ii), or (iii) of this section.	(2) Nonsafety-related electrical equipment whose failure under postulated environmental conditions could prevent satisfactory accomplishment of safety functions specified in subparagraphs (i) through (iii) of paragraph (b)(1) of this section by the safety-related equipment.

§54.4 – License Renewal Scope (see Table B-1)	**§50.49 - Environmental Qualification Scope (see Table B-2)**
{No corresponding criteria.}	(3) Certain post-accident monitoring equipment.
{No corresponding criteria.}	(c) Requirements for: (1) dynamic and seismic qualification of electrical equipment important to safety, (2) protection of electrical equipment important to safety against other natural phenomena and external events, and (3) environmental qualification of electrical equipment important to safety located in a mild environment are not included within the scope of this section.
(3) All systems, structures, and components relied on in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission's regulations for:	
-fire protection (10 CFR 50.48),	***{No corresponding criteria.}***
-environmental qualification (10 CFR 50.49),	*{Matches §50.49 scope}*
-pressurized thermal shock (10 CFR 50.61),	***{No corresponding criteria.}***
-anticipated transient without scram (10 CFR 50.62), and	***{No corresponding criteria.}***
-station blackout (10 CFR 50.63).	***{No corresponding criteria.}***

The differences in scope are identified and discussed below.

(a) **§50.49(b)(3)** - Certain post-accident monitoring equipment is included in EQ scope. **Determination:** These EQ components are within scope under §54.4 criteria only as a requirement of §50.49.

(b) **§50.49(c)(1)** - Excludes requirements for dynamic and seismic qualification of electrical equipment important to safety.
Determination: These requirements are civil/structural criteria and are not relevant to electrical component scope comparisons.

(c) **§50.49(c)(2)** - Excludes requirements for protection of electrical equipment important to safety against other natural phenomena and external events.
Determination: These requirements are civil/structural criteria and are not relevant to electrical component scope comparisons.

(d) **§50.49(c)(3)** - Excludes requirements for environmental qualification of electrical equipment important to safety located in a mild environment.
Determination: The Reactor Buildings are identified as EQ harsh environmental areas and all electrical equipment important to safety installed in the Reactor Buildings are within §50.49 scope. Therefore, this criterion is not relevant for a Reactor Building component scoping comparison.

(e) **§54.4(a)(3)** - Pressurized thermal shock (PTS) scope has no direct counterpart in §50.49.
Determination: PTS regulations do not pertain to electrical components.

(f) **§54.4(a)(3)** - Anticipated transient without scram (ATWS) scope has no corresponding criteria in §50.49.
Determination: No direct correlation is made that relates the scope of ATWS components to the scope of EQ components. All inputs and sensing devices used by the ATWS System are located outside the Reactor Buildings and all inputs feed equipment located outside the Reactor Buildings [Reference 25]. Therefore, this criterion is not relevant for a Reactor Building component scoping comparison.

(g) **§54.4(a)(3)** - Station blackout (SBO) scope has no direct counterpart in §50.49.
ITEM CARRIED FORWARD: Identification of electrical components within SBO (§50.63) scope are identified in the Oconee Station Blackout Coping Study. Some electrical components (and associated insulated cables and connections) within SBO (§50.63) scope installed in the Reactor Buildings are not within the scope of §50.49. This item is carried forward to the results given in Section 5.2.2.

(h) **§54.4(a)(3)** - Fire protection (FP) scope has no direct counterpart in §50.49.
ITEM CARRIED FORWARD: A direct comparison between FP scope and EQ scope is performed in the next section.

5.2.1.1 FP Scope Vs. EQ Scope For Insulated Cables & Connections In The Reactor Buildings

Insulated cables and connections included in the Oconee Fire Protection (FP) Program are those that fall within the scope of 10 CFR 50 Appendix R [Reference 26]. The following table gives a direct comparison of the component scoping requirements of 10 CFR 50 Appendix R to the component scoping requirements of §50.49.

Table 5-2
Comparison of Fire Protection & Environmental Qualification Scope

§50 Appendix R Section III Specific Requirements Involving Cables Needed for Safe Shutdown and Other Functions (see Table B-3)	§50.49 – Environmental Qualification Scope Most Closely Matching §50 Appendix R Criteria (see Table B-2)
F. Automatic fire detection. Automatic fire detection systems shall be installed in all areas of the plant that contain or present an exposure fire hazard to safe shutdown or safety-related systems or components. …	***{No corresponding criteria.}***
J. Emergency lighting. Emergency lighting units with at least an 8-hour battery power supply shall be provided in all areas needed for operation of safe shutdown equipment and in access and egress routes thereto.	***{No corresponding criteria.}***

§50 Appendix R Section III Specific Requirements Involving Cables Needed for Safe Shutdown and Other Functions (see Table B-3)	**§50.49 – Environmental Qualification Scope Most Closely Matching §50 Appendix R Criteria (see Table B-2)**
L. Alternative and dedicated shutdown capability. 1. Alternative or dedicated shutdown capability provided for a specific fire area shall be able to	
(a) achieve and maintain sub-critical reactivity conditions in the reactor;	(b)(1)(i) This equipment is that relied upon to remain functional during and following design basis
(b) maintain reactor coolant inventory;	events to ensure:
(c) achieve and maintain hot standby conditions for a PWR …;	(B) The capability to shut down the reactor and maintain it in a safe shutdown condition
(d) achieve cold shutdown conditions within 72 hours; and	*{EQ includes equipment required to achieve and maintain cold shutdown conditions [Reference 27,*
(e) maintain cold shutdown conditions thereafter.	*Section 1.0].}*
During the postfire shutdown, the reactor coolant system process variables shall be maintained within those predicted for a loss of normal a.c. power, and	(b)(1)(i) This equipment is that relied upon to remain functional during and following design basis events to ensure: (B) The capability to shut down the reactor and maintain it in a safe shutdown condition; and (C) The capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to the guidelines in §50.34(a)(1) or §100.11 of this chapter, as applicable. *{Postfire shutdown is hot shutdown. Hot shutdown equipment in the Reactor Buildings is included in the Oconee EQ Program; loss of normal a.c. power is bounded by the Station Blackout Analysis as described in the UFSAR [Reference 10, Sections 15.8.3, 8.3.2.2.4]}*
the fission product boundary integrity shall not be affected; i.e., there shall be no fuel clad damage, rupture of any primary coolant boundary, [or] rupture of the containment boundary.	(b)(1)(i) This equipment is that relied upon to remain functional during and following design basis events to ensure: (A) The integrity of the reactor coolant pressure boundary; (C) The capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to the guidelines in §50.34(a)(1) or §100.11 of this chapter, as applicable

2. The performance goals for the shutdown functions shall be:	
a. The reactivity control function shall be capable of achieving and maintaining cold shutdown reactivity conditions.	(b)(1)(i) This equipment is that relied upon to remain functional during and following design basis events to ensure: (B) The capability to shut down the reactor and maintain it in a safe shutdown condition *{EQ includes equipment required to achieve and maintain cold shutdown conditions [Reference 27, Section 1.0].}*
b. The reactor coolant makeup function shall be capable of maintaining the reactor coolant level … within the level indication in the pressurizer for PWRs.	(b)(1)(i) This equipment is that relied upon to remain functional during and following design basis events to ensure: (B) The capability to shut down the reactor and maintain it in a safe shutdown condition
c. The reactor heat removal function shall be capable of achieving and maintaining decay heat removal.	
d. The process monitoring function shall be capable of providing direct readings of the process variables necessary to perform and control the above functions.	(b)(3) Certain post-accident monitoring equipment. *{RG-1.97 Equipment is included, as appropriate, in Oconee EQ Program.}*
e. The supporting functions shall be capable of providing the process cooling, lubrication, etc., necessary to permit the operation of the equipment used for safe shutdown functions.	(b)(1) Safety-related electrical equipment. (2) Nonsafety-related electrical equipment whose failure under postulated environmental conditions could prevent satisfactory accomplishment of safety functions specified in subparagraphs (i) through (iii) of paragraph (b)(1) of this section by the safety-related equipment.
6. Shutdown systems installed to ensure postfire shutdown capability need not be designed to meet seismic Category I criteria, single failure criteria, or other design basis accident criteria….	(c)(1) dynamic and seismic qualification of electrical equipment important to safety, (2) protection of electrical equipment important to safety against other natural phenomena and external events, are not included within the scope of this section

The differences in the two scopes where the EQ scope does not bound FP scope are specific Appendix R requirements F (Automatic fire detection) and J (Emergency lighting). These differences, as they relate to insulated cables and connections in the Reactor Buildings, are discussed below.

Automatic Fire Detection

This requirement is met in part by the installation of fire detectors in appropriate locations. The Fire Detection System includes many components, but the only Fire Detection System components installed in the Reactor Buildings are fire detectors and the insulated cables that connect them to the rest of the Fire Detection System.

Emergency Lighting

How Oconee meets the requirement for emergency lighting is discussed in the *Specification for The Maintenance of the 10 CFR 50 Appendix R Program*. Specific access and egress routes are described. None of these access and egress routes involve entering the Reactor Buildings and no emergency lighting in the Reactor Buildings is credited for complying with §50.48.

5.2.1.2 Results — FP Scope Vs. EQ Scope For Insulated Cables & Connections In The Reactor Buildings

Insulated cables and connections used for fire detectors are the only FP (§50.48) insulated cables and connections installed in the Reactor Buildings that are not included in the EQ Program.

5.2.2 Results — Insulated Cables & Connections Included in the EQ Program

The results of the above analysis are given below:

(a) Oconee EQ insulated cables and connections installed in the Reactor Buildings include all insulated cables and connections meeting the criteria of §54.4(a)(1) and (2).

(b) Regarding the criteria of §54.4(a)(3):

- **(1) Fire detector insulated cables and connections are the only** FP (§50.48) insulated cables and connections installed in the Reactor Buildings that are subject to an AMR are included in the Oconee EQ Program.
- (2) PTS (§50.61) is not relevant to electrical components.
- (3) No ATWS (§50.62) components are installed in the Reactor Buildings.
- **(4) Some SBO (§50.63) scope insulated cables and connections installed in the Reactor Buildings are not included in the Oconee EQ Program.**

5.3 Results — Application of §54.21(a)(1)(ii) Screening Criteria

(1) Electrical penetration assemblies do not meet the criteria of §54.21(a)(1)(ii) and are not subject to an AMR.

(2) Insulated cables and connections included in the EQ program do not meet the criteria of §54.21(a)(1)(ii) and are not subject to an AMR.

(3) **Regarding insulated cables and connections installed in the Reactor Buildings:**
The only insulated cables and connections installed in the Reactor Buildings that are subject

to an AMR are SBO (§50.63) scope insulated cables and connections that are not included in the Oconee EQ Program and fire detector insulated cables and connections.

6
CHAPTER ASSIGNMENTS

The basic philosophy used in the electrical component IPA process is that all plant electrical components are included in the review unless they are specifically scoped-out or screened-out. Chapters 3, 4 and 5 give the results of the application of the scoping and screening criteria to electrical component commodity groups. A separate chapter is provided for each electrical component commodity group that is not scoped-out or screened-out.

The electrical component commodity groups reviewed are arranged alphabetically and listed in Table 6-1 along with the chapters to which they are assigned.

Table 6-1
Chapter Assignments for Electrical Component Commodity Groups

Electrical Component Commodity Groups	Chapter Assignment
Insulated Cables and Connections	Chapter 7
Insulators	Chapter 8
Isolated-Phase Bus	Chapter 9
Nonsegregated-Phase Bus	Chapter 10
Segregated-Phase Bus	Chapter 11
Switchyard Bus	Chapter 12
Transmission Conductors	Chapter 13

7
INSULATED CABLES AND CONNECTIONS

This chapter continues the electrical integrated plant assessment (IPA) by reviewing insulated cables and connections. All remaining electrical IPA work related to insulated cables and connections installed at Oconee is documented in this chapter. The process outlined in Figure 1-1 is followed in this chapter for insulated cables and connections.

A report published by the Department of Energy (DOE), *Aging Management Guideline for Commercial Nuclear Power Plants - Electrical Cable and Terminations* [Reference 8], provides a comprehensive compilation and evaluation of information on the topic of insulated cables and connections (i.e., terminations). As such, the information, evaluations and conclusions contained in this DOE cable aging management guide (DOE Cable AMG) are used in this review.

General Description

An insulated cable is an assembly of a single electrical conductor (wire) with an insulation covering or a combination of conductors insulated from one another with overall coverings. Cable connections are used to connect the cable conductors to other cables or electrical devices. Types of insulated cable connections (or terminations) are identified in the DOE Cable AMG [Reference 8, Section 3.3.2 and Appendix B Section B.2] and are listed below.

- **Compression Connectors:** Fittings (e.g., ring lugs or barrels) that are bolted, physically crimped or mechanically swaged to connect cable conductors.
- **Fusion Connectors:** Cable connections made by welding, brazing or soldering where permanence of conductor connection is desired.
- **Plug-in Connectors:** Connectors with one or more electrical contacts that plug or screw into a mating receptacle; useful where ease of separation of an electrical connection is desired, for ease of mating specific types of equipment and where multiple simultaneous electrical connections need to be made.
- **Splice Insulation Systems (heat-shrink or tape):** Insulation material generally applied over compression (e.g., bolted) or fusion connections and used to seal and insulate cable or splice terminations or junctions from the surrounding environment.
- **Terminal Blocks:** An insulating base with fixed points for landing of wiring or connection of terminal (ring) lugs. The terminal block connection type also includes fuse blocks. Terminal blocks are always installed in an enclosure such as a control board, motor control center, motor, terminal box or power panelboard.

Insulated cable connections are many times used in combinations such as a compression or fusion connection being used inside a plug-in connector.

Insulated cables and connections evaluated in this chapter are those that are not part of some larger complex assembly (e.g., cables internal to motors, switchgear, relays, transformers, power supplies, chargers, penetration assemblies). Insulated cables and connections that are part of some larger complex assembly are evaluated, as appropriate, in this specification as part of the larger assembly.

Insulated cables and connections are grouped by their applications as defined below.

- **Power Applications:** Insulated cables and connections used to supply power to devices or components where the cables carry a large amount of current, relative to their rating, for significant periods of time and, therefore, may be subject to self-heating temperature rise from the current they carry.
- **Non-power Applications:** Insulated cables and connections used to supply power to devices or components where the cables carry a small amount of current, relative to their rating, or carry current for short periods of time and, therefore, are not subject to significant self-heating temperature rise from the current they carry.

7.1 List — Insulated Cables & Connections

Chapter 3 concluded that insulated cables and connections associated with the 525kV Switchyard, the Radwaste Facility and the Oconee 44kV Retail substation are not subject to an AMR. Chapter 5 concluded that fire detector insulated cables and connections and environmentally qualified insulated cables and connections are not subject to an AMR. Therefore, an encompassing group (as described in Section 1.2) of plant insulated cables and connections except those (1) associated with the 525kV Switchyard, (2) associated with the Radwaste Facility, (3) associated with the Oconee 44kV Retail substation, (4) used for fire detectors or (5) included in the EQ program is included in the AMR.

Insulated cables and connections are grouped by their insulating materials and these groups are the basis for the required list of insulated cables and connections included in the aging management review. Cable insulation materials and cable connection insulation materials are identified separately in the following sections with a common list provided at the end of this section.

7.1.1 Cable Insulation Materials

Cable insulation materials were identified from a study that was performed to determine all the types of cable that are installed at Oconee. This study included review of a station cable database, station drawings and procurement documents. The types of cable at Oconee are identified by mark numbers and each cable type was purchased with specific insulation materials. The result of this study was a list all of the types of cables installed at Oconee and Keowee. The list includes cable application information that is identifies whether a cable type is used in power applications or non-power applications since this designation is needed to appropriately apply self-heating temperature rise. Information from the cable study is included in Table 7-1.

7.1.2 Cable Connection Insulation Materials

All the types of cable connections identified in the General Description are used at Oconee. All the brands and models of plug-in connectors, splice insulation systems and terminal blocks that were installed initially, or have been installed since, are not known. This being the case, the list of cable connection types consists of the brands and models whose materials it has been determined reasonably bound the materials of the plug-in connectors, splice insulation systems and terminal blocks actually installed in the plant, as described in Section 1.5. As discussed in Section 7.3, the materials identified include only organic materials.

Where application (i.e., non-power application or power application) information for cable connection types is not known, a bounding assumption is used that the cable connection materials are used in both non-power applications and power applications.

Insulation and jacket material names and acronyms are explained in Acronyms & Definitions.

Cable connections are listed as a separate application in Table 7-1. The materials included for each type of cable connection are discussed below.

Compression Connector Insulating Materials
Compression connections involve various types of metals and no organic materials. Therefore, compression connectors add no materials to the list.

Fusion Connector Insulating Materials
Fusion connections involve various types of welding and soldering metals and no organic materials. Therefore, fusion connectors add no materials to the list.

Plug-In Connector Insulating Materials
The component list for plug-in connectors includes brands and models (and materials) that likely bound the material characteristics of the various brands or models installed in the plant.

It is known that NAMCO limit switches, Rosemount pressure transmitters and CONAX RTDs are installed in the plant and all of them require connectors. The types of connectors typically used for this equipment are NAMCO EC210 connectors, Rosemount 353C connectors and various types of CONAX connectors. Therefore, these connector types are included in this AMR as the bounding set.

All of the plug-in connectors are similar in that they consist of a metal housing and facial grommet (inorganic material) that covers the lead wires. The lead wire materials are the materials subject to aging for plug-in connectors. The NAMCO interior lead wires can be produced by one of several manufacturers (e.g., Okonite (EPR), Rockbestos (XLPE), BIW (EPDM), or Kerite FR-3 (EPDM)) and are fed through polyolefin (XLPE) tubing (made by Alpha Corporation). The Rosemount lead wires are Kapton®-insulated, as are the CONAX lead wires.

NUREG/CR-6412 [Reference 28] is a recent study conducted for the NRC that tested conduit seals, connectors and splices that were chosen based on their usage in commercial nuclear power plants. As an added check, NUREG/CR-6412 was reviewed for connection materials. It was determined that all materials that were used in the construction of the connections included in NUREG/CR-6412 are identified in the preceding discussions. All connector materials included in NUREG/CR-6412 are included in this review.

The materials reviewed for plug-in connectors are:

- EPDM (Non-power and power applications)
- EPR (Non-power and power applications)
- Kapton (Non-power and power applications)
- XLPE (Non-power and power applications)

Splice Insulation System Insulating Materials

Table 7-2 shows that cables provided by Okonite, Kerite and Raychem are installed in the plant. These three manufacturers are the primary suppliers in the nuclear utility industry of splice kits or coverings to place over splices. The current splicing procedure [Reference 29] calls for use of a Raychem WCSF-N, NPKV, NPKP, or RNF-100 splice kit and Bishop W-962 or Scotch 130C as insulating tape for tape splices. Splices may include parts such as bolt padding, covers for insulating tapes and some general-purpose tapes may be used for cable jacket repairs. Aging degradation of the bolt padding or insulating tape covers would not affect the ability of a properly installed splice insulating tape or heat-shrink material to perform its intended function and are not included in this review.

Okonite insulating tape is made of EPR. Kerite splice kits use an EPR insulating tape. Raychem heat-shrinkable tubing splice kits (WCSF-N, NPKV, NPKP and RNF-100) are made of polyolefin (XLPE). Scotch 130C insulating tape is made of EPR. Bishop W-962 insulating tape is made of EPR. The materials reviewed for splice insulation systems are:

- EPR (Non-power and power applications)
- XLPE (Non-power and power applications)

Terminal Block Insulating Materials

The DOE Cable AMG [Reference 8, Table 3-1] lists all known manufacturers of terminal blocks installed in nuclear power plants. A search of the Oconee Work Management System (WMS) database identified four types of terminal blocks as being installed at the plant; Square D model SL400, Stanwick model DG-4, States Co. model M25012 and Buchanan model NQB/NQO. The Stanwick model is made of melamine and the States Co. and Buchanan models are made of phenolic. No information could be found concerning the Square D model. The weakest of all materials used to make terminal blocks is nylon. Nylon may have been used in some general purpose terminal blocks but it is reasonable that the purchase of any terminal blocks used in power applications would have specified a more durable material; phenolic being the most likely. Therefore, nylon for Non-power applications and phenolic for power applications are chosen as the bounding materials for the evaluation of terminal blocks. The materials to be included for terminal blocks are:

- Nylon (Non-power applications)

- Phenolic (Non-power and power applications)

7.1.3 Results — List

The list identifying the insulated cables and connections included in the AMR, grouped based on the insulation material, is given in the following table.

Table 7-1
Included in the AMR — Insulated Cables & Connections

Materials		Applications & Power Application Cable Sizes
Insulation	**Cable Jacket**	
AVA		**Non-power Application:** Special Grounding System
Butyl	PVC	**Power Application:** 600V Power; 350 MCM
EP, EPR, EPDM, FR-EP, FR-EPR	CPE, EPDM, FR-EP, FR-EPR, FR-Hypalon, FR-XLPE, Hypalon, Neoprene, PVC, XLPE	**Power Application:** 120/208 Lighting, 15kV Power, 1kV Power, 2kV Power, 4kV Power, 5kV Power, 600V Lighting Transformer, 600V Power, 600V Power, 7kV Power, 8kV Power, DC Test, Disc To Keowee Tailrace Valve, Inverter Power/Control, Lighting Power, Oconee-Keowee 15kV Power, Oconee-Keowee 5kV Power, Switchyard DC Power, Trace Heating; #10, #8, #6, #4, #2, #1, #1/0, #2/0, #3/0, #4/0 AWG, 250, 350, 500, 600 MCM; **Non-power Application:** 1kV Control, Annunicator Cable, Bailey System Communication, Bailey System Interconnection, Communication, Composite Cable, Computer Cable, Control, Festoon Cable (Fuel Handling), Hook-up Wire, Incore Instrumentation, Instrumentation, Lighting, PCS Interconnect, Radiation Monitors, RB Instrument, Switchyard Control, Switchyard Instrument, Thermocouple, Thermocouple Ext., Trace Heating, W/2 Coax; **Connections:** Plug-in Connectors (Power and Non-power Application), Splice Insulation Systems (Power and Non-power Application)
Fiberglass	PVC	**Non-power Application:** Incore Instrumentation, Thermocouple
Hypalon	Hypalon, Neoprene, PVC	**Power Application:** Rod Control, Festoon Cable; #4, #6, #8 AWG; **Non-power Application:** Control, Festoon Cable, RB Instrumentation, Rod Control, Thermocouple Extension, RB Thermocouple
Kapton		**Power Application:** Pressurizer Heater; #6 AWG; **Connections:** Plug-in Connectors (Power and Non-power Application)
Kerite-HTK	PVC	**Power Application:** 600V Power, 2kV Power; #10, #6, #2, #2/0 AWG, 250, 500 MCM
Nylon		**Connections:** Terminal Blocks (Non-power Application)
PE	PE, PVC	**Power Application:** 120/208V Lighting; #2, #2/0 AWG, 250 MCM; **Non-power Application:** 52 Ohm Carrier & Transfer Trip, Belden 8216, Belden 8221 TV Cable, Belden 8280 TV Camera, Communication, Incore Instrumentation, LAN, Lighting, Nuclear Instrumentation, RC Pump Vibration Monitor, Special Shielded Pair Cable, Telephone, Video Pair For Carrier Relays
Phenolic		**Connections:** Terminal Blocks (Power and Non-power Application)
Polyalkene		**Non-power Application:** General Purpose Hook-up
Polypropylene	Chrome/ Vinyl, PVC, PVF	**Non-power Application:** Annunciator, Hook-Up Wire

Materials		Applications & Power Application Cable Sizes
Insulation	**Cable Jacket**	
PVC, Vinyl	FR-PVC, Hypalon, Neoprene, PE, PVC, Vinyl	**Non-power Application:** 230 Switchyard Computer Cable, Annunicator Cable, Bailey System Communication, Bailey System Interconnection, Belden 8261 CCTV Camera, Belden 8280 TV Camera, Belden 8286 TV Camera, Belden 8468 TV Cable, Belden 8722, Communication, Computer, Control, CRD, ECH (by GE), Fire Alarm, ICS Simulator , Incore Instrumentation, Instrumentation, Alarms, Keowee To Oconee Interface, Lighting, Office Use, PA System, Process Radiation Mon., Thermocouple Cable, Voice Paging System
Silicone Rubber		**Power Application:** Rod Control, Control Rod Drive, 600V Power; #4, #8, #3/0 AWG, 300, 500 MCM; **Non-power Application:** Control Rod Drive, Radiation Monitors
Teflon	Tefzel	**Non-power Application:** Communication, Computer
Tefzel	Tefzel	**Power Application:** Rod Control; #6, #5 AWG
XLP, XLPE, Vulkene, FR-XLPE	CPE, FR-EP, FR-EPR, FR-Hypalon, FR-XLPE, Hypalon, Neoprene, PE, PVC	**Power Application:** 2kV Power, 1kV Power, 120/208 Lighting, Instrumentation, Control; #10, #8, #6, #2, #1/0, #2/0, #4/0 AWG, 250, 350, 500 MCM; **Non-power Application:** 120/208 Lighting, 1kV Control, Alarms, Annunicator Cable, Bailey System Communication, Bailey System Interconnection, CCTV Camera Interconnect, Communication, Composite Cable, Computer, Control, Control Board To Non-power Cabinet, Control Switchyard To Control Room, Fire Alarm, Hookup Wire, Incore Instrumentation, Instrumentation, PCS Interconnect, Radiation Monitors, RB Instrumentation, RB Thermocouple, RTD Cable, Security, Shielded Triple, Signals, Special Shielded Pair Cable, Station Control, Switchyard Control, Thermocouple, Thermocouple Ext. , Trash Rack Vibration Monitor; **Connections:** Plug-in Connectors (Power and Non-power Application), Splice Insulation Systems (Power and Non-power Application)

The known manufacturers of Oconee insulated cables are listed in the following table. The manufacturers represent all cables installed during initial construction. Cables in the latter years of Oconee operation were purchased commercial grade and could be manufactured by a company other than those identified in the following table. Cable insulation materials are not linked directly with specific manufacturers and, therefore, the aging management review takes a bounding approach that any of the insulated cable types could have been supplied by any of the listed manufacturers in addition to any other manufacturers of cable not listed.

Table 7-2
Insulated Cable Manufacturers

Company Name	
Anaconda	Okonite
BIW	Raychem
Brand Rex	Samuel Moore (Eaton)
ITT Surprenant	Rockbestos
Kerite	

Insulated cables and connections are installed in all plant structures and several areas outside structures. All plant structures and areas included in the electrical component AMR are identified in Table A-1 and are listed in the table below.

Table 7-3
Locations Containing Insulated Cables & Connections Included in the AMR

Structure or Area
Auxiliary Buildings
Earthen Embankments
Essential Siphon Vacuum Building
Intake Structure
Keowee Structures
Reactor Buildings
Standby Shutdown Facility
Turbine Buildings
Yard Structures
All remaining plant structures and areas

7.2 Component Boundaries — Insulated Cables & Connections

Insulated cables and connections connect two elements in an electrical circuit. These elements include any type of electrical device or component such as those listed in Table 2-1. Most electrical connections are made inside an electrical box, cabinet or enclosure such as a switchgear, power panelboard, control cabinet, connection box on skid mounted equipment or an equipment enclosure such as a transformer fan housing. Insulated cables and connections inside these enclosures are considered part of the electrical enclosure and, if the enclosure is part of (or supplied with) the electrical component, the enclosure insulated cables and connections are considered part of the electrical component. In addition, some cables terminate at a connector which directly connects with and is considered part of the end device (e.g., the pressurizer heater cable connectors). These connectors are not within the component boundary included in this review. These boundaries are justified since the connections to electrical components and connections inside electrical enclosures are considered part of that electrical component or enclosure and are inspected and maintained as part of the electrical component or enclosure.

Insulated cables and connections interface with structural steel supports (e.g., cable trays, conduit, cable trenches) connected to steel structures which are reviewed, as appropriate, in the structures and structural components AMR specification for license renewal [Reference 30].

7.3 Materials — Insulated Cables & Connections

The figure below shows a cross-section of a typical power cable installed at Oconee.

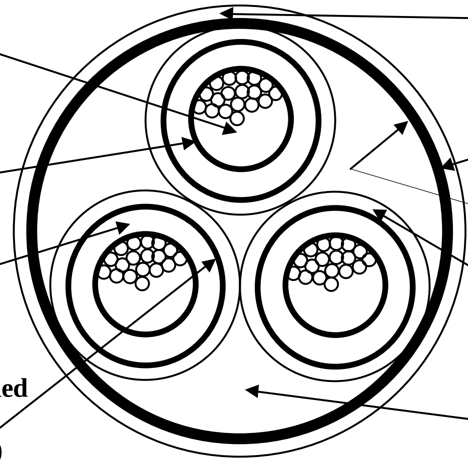

Figure 7-1
Cross-Section of a Typical Oconee Power Cable

The insulated cables and connections insulation materials along with their application (Non-power or power) are identified in Table 7-1. In addition to the insulation, there are other parts of insulated cables and connections such as the cable jacket, cable conductor, cable shielding, cable fillers, cable armor, conductor termination parts, plug-in connector pins, plugs and facial grommets. Cable jackets are used to protect the cable insulation during installation and cable jackets and their materials have no significant effect on the normal aging process of the primary cable insulation. The other parts of insulated cables and connections are constructed of metal and other inorganic materials. There are no significant aging effects for inorganic materials associated with cables. These materials are not included in this review.

Cable materials included in the AMR are listed in the following table along with the applications.

Table 7-4
Materials Reviewed — Insulated Cables & Connections

Insulation Material	Power Application		Non-Power Application	
	Cable	Connection	Cable	Connection
AVA			•	
Butyl	•			
EP, EPR, EPDM, FR-EP, FR-EPR	•	•	•	•
Fiberglass			•	
Hypalon	•		•	
Kapton	•	•		•
Kerite-HTK	•			
Nylon				•
PE	•		•	
Phenolic		•		•
Polyalkene			•	

Insulation Material	Power Application		Non-Power Application	
	Cable	Connection	Cable	Connection
Polypropylene			•	
PVC, Vinyl			•	
Silicone Rubber	•		•	
Teflon			•	
Tefzel	•			
XLP, XLPE, Vulkene, FR-XLPE	•	•	•	•

7.4 Service Conditions — Insulated Cables & Connections

The two aspects of service conditions—environmental conditions and self-heating temperature rise—are discussed below in separate sections.

7.4.1 Environmental Conditions

Insulated cables and connections included in the AMR are installed in the locations identified in Table 7-3.

The environmental conditions in some Reactor Building areas stress electrical components more than other plant areas. The following section determines the insulation materials of Reactor Building cables subject to an AMR.

7.4.1.1 Reactor Building Insulated Cables Subject To An AMR

Section 0 (page 5-7) gave the results of a review which determined that SBO (§50.63) scope insulated cables that are not included in the Oconee EQ Program and fire detector insulated cables are the only Reactor Building insulated cables subject to an AMR. This section determines what cable insulating materials need to be reviewed for the Reactor Buildings.

SBO Scope Cables Insulation Materials
Identification of electrical components relied on in safety analyses or plant evaluations to perform a function that demonstrates compliance with the Commission’s regulations for SBO (§50.63) are identified in the Oconee SBO Coping Study. The alternate AC power source for Oconee is the Standby Shutdown Facility (SSF).

The list of components needed to cope with an SBO (as listed in the Oconee SBO coping study) were screened to eliminate components located outside the Reactor Buildings and components in the Oconee EQ Program. The components remaining on the list identify all components that are required for SBO coping, are not in the EQ Program and are located in the Reactor Buildings. All components in the list are fed from the SSF and the associated insulated cables and connections originate in the SSF.

Regarding the cables to this equipment in the list, the Oconee SBO Coping Study states the following:

> **Oconee SBO Coping Study, Coping Analysis #3**
>
> *New cable was run to all SSF equipment with the exception of the pressurizer heaters. Only LOCA qualified, inside containment type cable was specified during the installation of the SSF. …*
>
> *The originally installed pressurizer heater Kapton insulated cables, which run from the pressurizer to the terminal box, were not replaced during SSF installation. Kapton insulated cables was originally chosen because of its high temperature capabilities. Kapton insulated cable is designed for normal operational temperatures higher than the Oconee postulated LOCA temperature. Underwriters Laboratories Inc. lists a thermal index of 200 C - 210 C for mechanical properties and 230 C - 240 C for electrical properties under their file no. E39505 for "Kapton" polyimide film. …*

One pressurizer group per unit was rerouted to be fed from the SSF during SSF construction. The cables between pressurizer terminal boxes and the electrical penetration assemblies was replaced for some units but not for others. The cable database indicates that the cable types installed are 3XJ2/0G2 and 3XJ2G2. If these are original cables, the cable study (Section 7.1.1) show these to be EPR insulated cables. If the cables were replaced during the SSF installation in the mid-1980's, they are constructed with either FR-XLPE or FR-EPR insulation [Reference 31].

Fire Detector Cables Insulation Materials

The cable used to install the fire detectors is type SPXJ16G.3, single shielded pair, interlocked armor with overall jacket, #16 AWG wire, general use, 300V insulation. This type of cable is constructed with XLPE insulation [Reference 32].

Therefore, the Reactor Building cables subject to an AMR have the following insulation materials.

- EPR, FR-EPR, FR-XLPE (Between pressurizer terminal box and penetration)
- Kapton (Between pressurizer and pressurizer terminal box)
- XLPE (fire detector cables)

7.4.1.2 Results — Environmental Conditions

The environmental conditions data included in Chapter 15 for thermal environments (Table A-2), radiation environments (Table A-3) and moisture environments (Table A-4) was used in the following table. This table outlines the insulated cables and connections environmental conditions. Regarding Reactor Building thermal environments listed in Table A-2, the insulated cables and connections subject to an AMR are not located near the vessel head or the area around the control rod drives but may be located in high elevations in the steam generator cavities.

Table 7-5
Environmental Conditions — Insulated Cables & Connections

Stressor	Structure or Area	Insulation Material	Bounding Value
Temperature	Reactor Buildings	EPR, FR-EPR, Kapton, FR-XLPE, XLPE	132°F (55.6°C)
	Auxiliary Buildings Earthen Embankments Essential Siphon Vacuum Building Intake Structure Keowee Structures Standby Shutdown Facility Turbine Buildings Yard Structures All remaining plant structures and areas	All insulation materials	105°F (40.6°C)
Radiation	Reactor Buildings	EPR, FR-EPR, Kapton, FR-XLPE, XLPE	4.5×10^7 rads
	Auxiliary Buildings	All insulation materials	1.5×10^6 rads
	Turbine Buildings	All insulation materials	less than 1.5×10^3 rads
	Earthen Embankments Essential Siphon Vacuum Building Intake Structure Keowee Structures Standby Shutdown Facility Yard Structures All remaining plant structures and areas	All insulation materials	Negligible
Moisture		Specific Area	
	Intake Structure Earthen Embankments Yard Structures All remaining plant structures and areas	Areas exposed to outside ambient conditions	Precipitation
	Keowee Structures	Turbine shaft wells	Water seepage through a wall
	Yard Structures All remaining plant structures and areas	Cable trench	Standing water on trench floor
		Direct buried	Surface water drainage and soil moisture
		Buried Conduit	Water collection

7.4.2 Self-Heating Temperature Rise

Self-heating temperature rise applies only to power cables and connections. It is reasonable that due to the general design of cable connections, their self-heating temperature rise is equal to or less than that for the cables. Therefore, only cable self-heating temperature rise values are determined.

Three databases of power system loads were used. The databases are used to perform load and voltage calculations for the Oconee power system. These databases contain information for each load (e.g., bus, compartment, description, voltage, load, load factors) connected to each power system bus. These databases were combined and converted into spreadsheet format for use in calculating self-heating temperature rise. The loads in the spreadsheet were then matched with the power system one-line diagrams to identify the number of conductors and the conductor size for each load.

The conductor ampacities are calculated starting with values in a IEEE S-135/IPCEA P-46-426 table [Reference 33, page 309] designated for cables with three concentric strand copper conductors, 90°C rated rubber insulation, in 104°F (40°C) ambient air. [Footnote 2] The 1kV column values in the IPCEA table are used for all cables except for the Reactor Coolant Pump motor cables. Reactor Coolant Pump motor (6900V system) cables have 15kV insulation and the 15kV column ampacity is used. Using the IPCEA table values in this way is standard Duke practice as outlined in DC-3.12 [Reference 34, Section 6.1]. Ampacities for 600 MCM conductors (not shown in the IPCEA table) are calculated by interpolating between the 500 MCM and 750 MCM values. Ampacities for #10 and #12 AWG (also not shown in the IPCEA table) are taken from the National Electric Code (NEC) [Reference 35, Table 310-16 (copied in Reference 34 as Table 3, page 6)] for 90°C rated copper conductors.

In accordance with Design Criteria DC-3.13 [Reference 36, Section 6.2] power cables are placed in ladder trays only one layer deep and separated from one another by an average of at least one fourth of the largest cable diameter. So the ampacities are then derated with a multiplying factor (0.82) for single-layer horizontal placement in ladder tray with maintained spacing given in IEEE S-135/IPCEA P-46-426 [Reference 33, Table VII]. The #10 and #12 AWG values in the NEC table are given for a 86°F (30°C) ambient, so these cables are derated by an additional correction factor (0.91) for use in a 104°F (40°C) ambient — resulting in a 0.7462 multiplying factor (0.82 x 0.91) for these size conductors [Reference 37]. The conductor sizes, initial ratings, derating factors and resulting conductor ampacities are shown in the following table.

2. **104°F (40°C) vs. 105°F (40.6°C):** The difference between 104°F (40°C) and the bounding 105°F (40.6°C) ambient temperature given for most cables per Table 7-5 is not significant for calculating cable ampacities.

Table 7-6
Conductor Ampacities And Derating Factors

Conductor Size (AWG or MCM)	IPCEA Table Cable Ampacity	Ampacity Derating Factor	Conductor Ampacity
12	30	0.7462	22.4
10	40	0.7462	29.8
8	59	0.82	48.4
6	79	0.82	64.8
4	104	0.82	85.3
2	138	0.82	113.2
1	161	0.82	132.0
1/0	186	0.82	152.5
2/0	215	0.82	176.3
3/0	249	0.82	204.2
4/0	287	0.82	235.3
250	320	0.82	262.4
350	394	0.82	323.1
500	487	0.82	399.3
600	538	0.82	441.2
600 (15kV insulation)	589	0.82	483.0

These current ratings were entered into a spreadsheet and the combined data is used to calculate the self-heating temperature rise that occurs when each is conductor is carrying its normal connected load [Reference 38]. The calculated temperature rises were sorted in descending order.

This sorting produced 30 distinct self-heating temperature rise values that are greater than 10°C. Comparing the conductor size and voltage on the spreadsheet list to the power cable applications and conductor sizes identified in Table 7-1, possible insulation types are identified for each distinct value in the list. For example, 4kV and 7kV applications use only EP, EPR, EPDM, or FR-EPR insulated cables; 600 MCM conductors are only found in EP, EPR, EPDM, or FR-EPR insulated cables; PE insulated cables are used at a maximum of 208V applications; Kapton insulated cables are only used in one application with a #6 conductor. Possible cable insulation types were identified for each of the temperature rise values.

Included in the spreadsheet calculation are the Reactor Building SBO/SSF cables discussed in Section 7.4.1.1. A review of the cables for components identified in the Oconee SBO coping study shows that the only cables used in a power application are pressurizer heater cables. The complete pressurizer heater cable circuit was not modeled in the voltage calculation databases, so a preliminary self-heating temperature rise calculation was performed for the SBO/SSF pressurizer heater cables [Reference 38]. The bounding self-heating temperature rise for all cables in the SSF pressurizer heater cable circuit is included in Table 7-7. As indicated in Section 7.4.1.1, the SSF pressurizer heater cables are insulated with EPR, FR-EPR, Kapton or FR-XLPE.

The self-heating temperature rise calculation results for calculated values greater than 10°C are provided in the following table.

Table 7-7
Calculated Self-Heating Temperature Rise

Calculated Self-Heating Temperature Rise	Conductor Size	Load Voltage	Possible Insulation Types
29.65°C	250 MCM	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
25.83°C	600 MCM	6900V	EP, EPR, EPDM, FR-EP, FR-EPR
24.16°C	500 MCM	4160V	EP, EPR, EPDM, FR-EP, FR-EPR
23.39°C	#10 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
23.27°C	#2/0 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
23.02°C	#2 AWG	4160V	EP, EPR, EPDM, FR-EP, FR-EPR
20.53°C	500 MCM	4160V	EP, EPR, EPDM, FR-EP, FR-EPR
19.79°C	600 MCM	4160V	EP, EPR, EPDM, FR-EP, FR-EPR
18.98°C	250 MCM	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
18.08°C	#2 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
17.65°C	#6 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
17.54°C	#10 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
16.83°C	600 MCM	4160V	EP, EPR, EPDM, FR-EP, FR-EPR
16.69°C	#6 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
15.13°C	250 MCM	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
15.02°C	#3/0 AWG	4160V	EP, EPR, EPDM, FR-EP, FR-EPR
14.97°C	#10 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
14.90°C	#2/0 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
13.79°C	#6 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
13.64°C	600 MCM	4160V	EP, EPR, EPDM, FR-EP, FR-EPR
12.71°C	#6 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
12.57°C	#2/0 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
12.37°C	#10 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
11.82°C	#2/0 AWG	600V	EPR, FR-EPR, Kapton, FR-XLPE [SBO/SSF]
11.69°C	#10 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
11.17°C	#6 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
10.73°C	#2/0 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
10.39°C	#10 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
10.34°C	#6 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK
10.17°C	#2 AWG	600V	EP, EPR, EPDM, FR-EP, FR-EPR, Kerite-HTK

The highest calculated self-heating temperature rise of 29.65°C is used as the value for EP, EPR, EPDM, FR-EP, FR-EPR and Kerite-HTK. In addition, this bounding self-heating temperature rise is applied to the power application connection materials identified in Table 7-4. The remaining cable insulation materials identified in Table 7-4 as being used in power applications are given a bounding 10°C self-heating temperature rise. The SBO/SSF pressurizer heater cable self-heating temperature rise is listed separately and is conservatively applied to other SBO/SSF Reactor Building power application cables subject to an AMR in addition to the fire detector cables insulation, XLPE. The self-heating temperature rise for all insulation materials used only for non-power application is not significant.

Table 7-8
Self-Heating Temperature Rise — Insulated Cables & Connections

Insulation Material	Bounding Self-Heating Temperature Rise
EP, EPR, EPDM, FR-EP, FR-EPR, Kapton, Kerite-HTK, Phenolic, XLP, XLPE, Vulkene, FR-XLPE	29.65°C
EPR, FR-EPR, Kapton, FR-XLPE, XLPE [Reactor Building]	11.82°C
Butyl, Hypalon, PE, SR, Tefzel	10.0°C
AVA, Fiberglass, Nylon, Polyalkene, Polypropylene, PVC, Vinyl, Teflon	Not significant

7.4.3 Results — Service Conditions

Service conditions for insulated cables and connections are obtained by combining the environmental conditions data given in Table 7-5 with the self-heating temperature rise values given in Table 7-8. The results are given in the following table.

Table 7-9
Service Conditions — Insulated Cables & Connections

Stressor	Structure or Area	Insulation Material	Bounding Value
Temperature	Auxiliary Buildings Earthen Embankments Essential Siphon Vacuum Building Intake Structure Keowee Structures Standby Shutdown Facility Turbine Buildings Yard Structures All remaining plant structures and areas	EP, EPR, EPDM, FR-EP, FR-EPR, Kapton, Kerite-HTK, Phenolic, XLP, XLPE, Vulkene, or FR-XLPE	158.45°F (70.25°C)
		Butyl, Hypalon, PE, SR, Tefzel	123.1°F (50.6°C)
		AVA, Fiberglass, Nylon, Polyalkene, Polypropylene, PVC, Vinyl, Teflon	105°F (40.6°C)
	Reactor Buildings	EPR, FR-EPR, Kapton, FR-XLPE, XLPE	153.4°F (67.42°C)
Radiation	Reactor Buildings	EPR, FR-EPR, Kapton, FR-XLPE, XLPE	4.5×10^7 rads
	Auxiliary Buildings	All insulation materials	1.5×10^6 rads
	Turbine Buildings	All insulation materials	less than 1.5×10^3 rads
	Earthen Embankments Essential Siphon Vacuum Building Intake Structure Keowee Structures Standby Shutdown Facility Yard Structures All remaining plant structures and areas	All insulation materials	Negligible

Stressor	Structure or Area	Specific Area	Bounding Value
Moisture			
	Intake Structure Earthen Embankments Yard Structures All remaining plant structures and areas	Areas exposed to outside ambient conditions	Precipitation
	Keowee Structures	Turbine shaft wells	Water seepage through a wall
	Yard Structures All remaining plant structures and areas	Cable trench	standing water on trench floor
		Direct buried	surface water drainage and soil moisture
		Buried Conduit	water collection

7.5 Aging Effects — Insulated Cables & Connections

Insulated cables and connections aging effects assessment data is most often generated for and applied to meeting §50.49 environmental qualification (EQ) requirements. As such, these data are related to EQ insulated cables and connections that are required to remain functional during and after being subjected to an accident (harsh) environment. As determined in Section 6.2, EQ insulated cables and connections are not subject to an AMR. The Oconee EQ Program is driven from the scope and requirements of §50.49, which excludes "electrical equipment important to safety located in a mild environment" from its scope. As defined in §50.49 [Reference 39]:

> **§50.49(c)**
>
> *A mild environment is 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.*

Although not stated or named in §50.49, the converse of a "mild" environment has been identified at Oconee as a "harsh" environment. Harsh environments are defined by rooms or defined areas whose environment can be significantly influenced by an accident whereas mild environment areas are all non-harsh environment areas. All spaces at Oconee are identified as either harsh or mild. The definitions used at Duke, per IEEE Standard 323 and a Duke Power Nuclear Policy Directive, for Oconee are given below.

> **Duke Power Nuclear Policy Directive**
>
> ***Harsh Environment***
> *An environment expected as the result of the postulated service conditions appropriate for the design basis and post-design basis accidents of the stations. Harsh environments are the result of a loss of coolant accident (LOCA), high energy line break (HELB), or post-LOCA recirculation radiation.*
>
> ***Mild Environment***
> *An environment expected as a result of normal service conditions and extremes (abnormal) in service conditions where seismic is the only design basis event (DBE) of consequence.*

The following contrasts the requirements of insulated cables and connections included in the Oconee EQ Program (subject to a harsh environment) to the requirements of mild environment insulated cables and connections included in the AMR.

Mild Environment Insulated Cables & Connections	Harsh Environment Insulated Cables & Connections
are located in an area that will not have any significant environmental change during a design basis accident	are located in an area that is subject to an accident environment
may (depending on function) be required to function to mitigate the consequences of an accident	must function to mitigate the consequences of an accident and, therefore
may (depending on function) be required to maintain the ability to perform its function during and after a seismic design basis event (DBE)	must maintain the ability to perform its function during and after being subjected to an accident environment

The requirements for insulated cables and connections included in the AMR, as they relate to accident environments, are covered above under Mild Environment Insulated Cables & Connections.

A major concern with insulated cables and connections is stated in the statement of considerations (SOC) for the final license renewal rule [Reference 1]:

SOC for 10 CFR 50, Section III.f.(i)(a), "Passive" Structures and Components

The major concern is that failures of deteriorated cable systems (cables, connections, and penetrations) might be induced during accident conditions.

This same major concern was stated in NUREG/CR-5643, "Insights Gained From Aging Research" [Reference 40]. The following are quotes from NUREG/CR-5643 stating its background, purposes and some specific results pertaining to mild environment cables.

NUREG/CR-5643, "Insights Gained From Aging Research"

This document was developed to consolidate the research results from the assessments of component and system aging sponsored by the NRC for use by industry and by NRC in understanding and managing the aging of systems, structures, and components in nuclear power plants.

The "Aging Management Guide" is a more concise document which provides some general observations of the effects of aging on the component or system. The Guide lists recommendations, associated with the maintenance, operations, design, and testing which the research has shown could be beneficial to understanding and managing the aging of that component or system.

NUREG/CR-5643, "Insights Gained From Aging Research"

The statements and recommendations made in this document are based on assessments of operating experience, evaluations of material, testing of naturally aged equipment, and identification of operating and environmental stresses. The perspectives expressed do not reflect regulatory positions or requirements.

OPERATING EXPERIENCE
Cables have an excellent functional operating history in nuclear power plants. The number of failures as reflected by the LER database is extremely small under normal operating conditions. The major concern with cables, however, is the performance of aged cable when it is exposed to accident conditions.

AGING ASSESSMENT GUIDE — CABLES
Observations on the aging of cables
— "Mild environment" cables are of little concern.

Since insulated cables and connections included in the AMR will not be affected by an accident environment, the major concern stated in the SOC and in NUREG/CR-5643 for insulated cables and connections does not apply to the insulated cables and connections included in the AMR. Therefore, aging effects of the insulated cables and connections included in the AMR are of little concern for overall plant nuclear safety.

Aging Effects Assessment
The DOE Cable AMG [Reference 8] provides a comprehensive compilation and evaluation of information on the topic of aging and aging management for cables and their associated connections (i.e., terminations). The DOE Cable AMG evaluated the stressors acting on cable and connection components, industry data on aging and failure of these components and the maintenance activities performed on cable systems. Also evaluated were the main subsystems within cables, including the conductors, insulation, shielding, tape wraps, jacketing and drain wires, as well as all subcomponents associated with each type of connection. The principal aging mechanisms and anticipated effects resulting from environmental and operating stresses on these systems were identified, evaluated and correlated with plant experience to determine whether the predicted effects are consistent with field experience. Installation stressors were also examined [Reference 8, Section 1.3, page 1-3]. As such, the information, evaluations and conclusions contained in the DOE Cable AMG are used as the starting point for the evaluation of aging effects in this specification. Additional or background information pertaining to items covered in this section is discussed in more detail in the DOE Cable AMG or other referenced sources.

The DOE Cable AMG categorizes aging mechanisms as being either "significant" or "significant and observed." Under the direction of the DOE, all possible (including hypothetical) aging mechanisms were to be included in the AMG. Drafts of the AMG initially indicated that most of the aging mechanisms are not significant (i.e., not important or of consequence). However, in the final document, these same aging mechanisms are identified as "significant" and a new classification of "significant and observed" is used to identify those mechanisms that are observed in the industry. Per DOE Cable AMG Section 4.2.2, the classification of "significant and observed" "*helps eliminate purely 'hypothetical' aging mechanisms and effects.*"

7.5.1 Review of "Significant" Aging Mechanisms & Stressors

In the NRC staff requests for additional information (RAIs) [Reference 11, Attachment 3, RAI 3.6-2], Duke was requested to address specific "significant" aging mechanisms identified in the DOE Cable AMG as they relate to Oconee. As explained earlier in this section, these "significant" aging mechanisms were previously identified as not significant (i.e., not important or of consequence) and are now categorized in the DOE Cable AMG as being "significant."

Section 4.2 of the DOE Cable AMG emphasized that "*the applicability of some aging mechanisms to actual cable systems may be very limited or the frequency of their occurrence may be extremely low*"...[and]..."*even these principal aging mechanisms are often of little consequence to the continued functionality of the plant cable systems as a whole.*" After a consideration of all the stressors and the reported incidence of their effects in the industry, the DOE Cable AMG concluded that "*the likelihood of substantially increased effects or failure rate resulting from aging mechanisms currently categorized only as 'significant' is considered low.*" This assessment, which is based on industry wide observations that include Oconee operating experience, provides reasonable assurance that these aging mechanisms will not cause a loss of intended function if left unmanaged during the extended period of operation.

The RAI responses that addressed these "significant" aging mechanisms are provided below.

a. ELECTRICAL STRESSORS

- **Energization at Normal Voltage Levels**
  The amount and severity of this stress is determined primarily by the dielectric strength and thickness of the insulating material used and the operating voltage and frequency. Published data indicate that insulation breakdown due to energization at normal operating voltages is of limited concern, based on the comparatively low applied voltage stress. Cables are designed to specific voltage ratings that equal or exceed the cable operating voltage. Therefore, energization at normal voltage levels is not a significant stressor and associated aging effects are not applicable.

- **Transient Conditions**
  Voltage and current surges can stress the dielectrics of the cable and associated connections and contribute to breakdown of insulation. These transients are considered in the design and selection of electrical system components. Cables are manufactured, selected and installed with sufficient insulation thickness to withstand voltage stress. Cable connections are matched to the performance of the cable system. Therefore, transient conditions are not significant stressors and associated aging effects are not applicable.

- **Partial Discharge**
  This effect results from large potential gradients between materials separated by air or similar media. Partial discharge can occur between conducting components internal to the cable structure or between insulators separated by a gaseous medium. Factory testing, installation and termination techniques are designed to preclude partial discharge. Partial discharge is a

consequence of improper manufacturing or improper termination techniques, which are not age-related and does not require an aging management review.

- **Effects of [Moisture and] Contaminants**
  Although stated in the RAI as "Effects of Contaminants," the title of this stressor in the DOE Cable AMG is "Effects of Moisture and Contaminants." Dry contaminants cause no aging effects. Moisture is addressed as a "significant and observed" aging mechanism in Section 7.5.2.

- **Indications of Electrical Degradation**
  This discussion topic in the DOE Cable AMG is intended to be illustrative of other *indications* of aging. However, the topic is not an aging mechanism itself and does not identify any new aging mechanisms that are not already addressed in the other discussions. Therefore, this topic is not applicable.

- **Effects of High-potential Testing on XLPE-insulated Cables**
  High-potential testing is only performed on shielded, medium-voltage cables. Oconee does not use XLPE-insulated cables in medium-voltage applications (see Table 7-1). Therefore, this aging stressor is not applicable.

b. MECHANICAL STRESSORS

- **Vibration**
  Vibration is generally induced in cables and connections by the operation of external equipment such as compressors, fans and pumps. Vibration can affect cable connections at a running motor by producing fatigue damage of the metallic cable or termination components in the immediate vicinity of the connection point. Terminations at equipment are part of the equipment and are inspected and maintained along with the equipment. These terminations are not within the component boundary for insulated cable and connections and are not included in the insulated cable and connection review.

- **Gravity-induced Cable "Creep" and Tensile Stress**
  Proper installation techniques including softened edges, rounded supports, proper supports and limitations on cable tray loading preclude gravity-induced cable creep and tensile stress. Gravity-induced cable creep and tensile stress is a consequence of improper installation, is not age-related and does not require an aging management review.

- **Compression**
  This aging stressor is not applicable to cables; it is of interest for o-rings, seals, gaskets and grommets used in connectors. O-rings, seals, gaskets and grommets used in connectors are replaced as necessary during routine maintenance. Therefore, these are consumable parts and compression is not an applicable stressor.

- **Installation-related Degradation**
  Degradation during cable installation is not an aging mechanism. Installation damage to cables might occur, but such damage is not age related and does not require an aging management review.

- **Maintenance/Operation-related**
  Degradation resulting from manipulation of cables and connections during maintenance or

testing is not an aging mechanism. External mechanical stresses may cause damage, but the stresses are not age related and do not require an aging management review.

c. CHEMICAL/ELECTROCHEMICAL STRESSORS

- **Chemical Attack of Organics and Cable Decomposition**
  There are no in-scope insulated cables and connections that are normally exposed to chemicals or chemical sprays during normal plant operating conditions. A chemical spill is event-driven; it is not an aging mechanism. The effects of random, inadvertent chemical spills, should they occur, would be evaluated at the time of the spill on a case-by-case basis. Therefore, chemical/electrochemical stressors are not applicable.

- **Loss of Fire Retardants**
  Loss of fire-retardant compounds in cable insulation and jacketing due to thermal aging or irradiation is considered insignificant. It has been demonstrated that the actual flammability of the most common insulation and jacketing materials (including XLPE, EPR and CSPE) either decreases, remains roughly constant, or only increases slightly, due to the competing effect of loss of other flammable volatiles within the chemical formulation. Therefore, aging effects associated with loss of fire retardants are not applicable.

- **Effects of Oxygen and Ozone**
  Oxygen: The effects of oxygen on aging involve the percent concentration of oxygen during the aging process (that is, the rate of aging can change for some materials if the percent of oxygen is less than ~20%). However, the typical thermal aging tests that are cited as the basis for aging studies involving the types of cables installed at Oconee were performed in forced-convection air ovens. Therefore, the concentration of oxygen in both the tests and the installed locations are similar and this stressor will not affect the rate of aging.
  Ozone: Degradation of certain organic insulation and jacketing materials may be affected by Ozone, which is generated as the result of the interaction of ionizing radiation with oxygen or by corona discharge ionization. Technical literature that addresses this aging stressor notes that it is applicable to SBR and Buna-N rubber. SBR and Buna-N are not used as cable insulations at Oconee. In summary, neither oxygen nor ozone effects are applicable.

This ends the review of “significant” aging mechanisms from the DOE Cable AMG that were identified in the NRC RAI. All of these “significant” aging mechanisms are found not applicable.

7.5.2 Review of “Significant & Observed” Aging Mechanisms & Stressors

The most significant and observed aging mechanisms for insulated cables and connections are listed in DOE Cable AMG [Reference 8, Table 4-18, page 4-81]. The aging mechanisms from this table are used in this specification as the starting point for identifying aging effects for insulated cables and connections with the following adaptations made for a license renewal AMR.

(a) Neutron detecting cables and connections are identified separately in DOE Cable AMG Table 4-18. Neutron detecting cables and connections are low voltage, I&C cables. Since neutron detecting cables and connections have the same applicable stressors and potential aging effects as low voltage cables and connections, they are included in the scope of low voltage cables and connections and are not listed separately.

(b) Low-voltage cable external mechanical stresses are identified in DOE Cable AMG Table 4-18. External mechanical stresses refer to stresses caused by physical interaction of operating personnel with cables and instances where cables are not well supported. External mechanical stresses may cause damage to the cable jacket or insulation, but this is maintenance or installation related damage, is not age-related and does not require an aging management review.

(c) Low-voltage cable compression fitting vibration and tensile stress are identified in DOE Cable AMG Table 4-18. Compression fittings subject to vibration and tensile stress occur at connections to an electrical component. As stated in the Section 7.2 these connections are considered part of the component and are not included in the cable review.

(d) An additional low-voltage cable heat aging effect of "increased vulnerability to failure in harsh environment" appears in DOE Cable AMG Table 4-18. This aging effect is only applicable to cables included in the Oconee EQ Program, which are not subject to an AMR (see Section 5.2).

(e) Cable jacketing is identified for low-voltage cable as a subcomponent along with insulation. Heat and radiation are identified as applicable stressors. Cable jackets are used to protect the cable insulation during installation and cable jackets and their materials have no significant effect on the normal aging process of the primary cable insulation. As such, aging of the cable jackets is not included in the review.

(f) Heat and radiation are not identified as applicable stressors for medium-voltage cable in DOE Cable AMG Table 4-18. Although the exclusion is justifiable based on observed industry failure data, it is prudent to consider these stressors applicable for medium-voltage cables.

The consideration of the "significant and observed" aging mechanisms result in a list of potential aging effects. The potential aging effects along with the applicable stressors that are evaluated for insulated cables and connections are presented in the following table and are discussed in the following sections. [Footnotes 3, 4]

Table 7-10
Potential Aging Effects — Insulated Cables & Connections
Adapted From DOE Cable AMG Table 4-18

Voltage Category [Footnote 5]	Component	Applicable Stressor	Potential Aging Effects
Low Voltage	Connector contact surfaces	Moisture, oxygen	Increased resistance and heating; loss of circuit continuity
Medium Voltage	Cable insulation	Moisture and voltage stress	Electrical failure (breakdown of insulation)
Low Voltage and Medium Voltage	Cable insulation	Radiation, oxygen	Reduced insulation resistance; electrical failure
		Heat, oxygen	Reduced insulation resistance; electrical failure

3. **Moisture and Low-Voltage Cable:** Although moisture is not identified as an applicable stressor for low-voltage cable in DOE Cable AMG Table 4-184-18 and is not included in this evaluation, not addressing it may raise questions. Moisture is not included as an applicable stressor for low-voltage cable insulation because the results of previous comprehensive studies have reached this conclusion. For example, there is no discussion in the Division of Operating Reactors (DOR) Guidelines ["Guidelines for Evaluating Environmental Qualification of Class IE Electrical Equipment in Operating Reactors," Enclosure 4 to "Environmental Qualification of Class IE Equipment," IE Bulletin 79-01B,79-01B, January 14, 1980, Office of Inspection and Enforcement, U.S. NRC] for environmental qualification (EQ) of electrical components concerning moisture or humidity for cables that must be capable of withstanding a loss of coolant accident (LOCA) or high energy line break (HELB). Even a more severe qualification standard, NUREG-0588 Rev. 1 ["Interim Staff Position on Environmental Qualification of Safety-Related Equipment Including Staff Responses of Public Comments, Resolution of Generic Technical Activity A-24,"A-24," July 1981, Office of NRR, U.S. NRC], specifically states the following in the aging discussion in Section 4.(8): "Effects of relative humidity need not be considered in the aging of electrical cable insulation." Finally, the DOE Cable AMG [Reference **8**, Section 3.7.4] reports the results of an EPRI study that states, "*…moisture-related failures of low-voltage*"*…moisture-related failures of low-voltage cable are not occurring…* [and] *…The overall conclusion of the study was that moisture-related degradation is not a significant concern for general applications.*"
applications."
4. **IPA & EQ Material Aging Information:** Most regulatory information related to cable aging effects is issued relative to environmentally qualified (EQ) cables and requirements. Requirements for EQ cables and connections are not relevant to cables and connections reviewed in this IPA but insights regarding applicable aging stressors for EQ components are valid for non-EQ components.
5. **Low Voltage:** less than 2kV
Medium Voltage: 2kV to 15kV

7.5.2.1 Low-Voltage Connector Contact Surfaces — Moisture, Oxygen

The DOE Cable AMG [Reference 8, Section 3.7.2.1.1.3] states that only 3% of all low-voltage connector failures were identified as being caused by moisture intrusion. Based on the total number of reported connector failures in the DOE Cable AMG, moisture intrusion accounted for 10 failures in all of the operating plants in the United States.

Structures and areas where electrical components may be exposed to moisture are indicated in Table 7-9. Connectors located in outside areas, such as the 230kV Switchyard and Intake Structures, are in enclosures and not exposed to direct precipitation. The moisture noted at Keowee was in the shaft well. This moisture came from wall seepage and is only enough seepage to cause mineral deposits on the wall. The moisture is not enough to cause collection in any area. Therefore, aging effects related to moisture and oxygen are not applicable for low-voltage connectors.

7.5.2.2 Medium-Voltage Cable Insulation — Moisture & Voltage Stress

DOE Cable AMG, Section 3.7.4, describes a survey of 25 fossil and nuclear power plants, which was conducted to determine the number and types of medium-voltage (defined in the DOE Cable AMG as 2kV to 15kV) cable failures that have occurred. The survey identified only 27 failures in almost 1000 plant years of experience. The bulk of the failures that did occur were more related to wetting in conjunction with manufacturing defects, or damaged terminations due to improper installation, which are not aging effects subject to aging management review.

The effects of moisture-produced water trees on medium-voltage cable were further examined in Section 4.1.2.5 the DOE Cable AMG. Water trees occur when the insulating materials are exposed to long-term, continuous electrical stress and moisture; these trees eventually result in breakdown of the dielectric and ultimate failure. The growth and propagation of water trees is somewhat unpredictable and few occurrences have been noted for cables operated below 15kV. Water treeing is a degradation and long-term failure phenomenon that is documented for medium-voltage electrical cable with XLPE or high molecular weight polyethylene (HMWPE) insulation.

As shown in Table 7-1, Oconee does not use XLPE or HMWPE insulated cables in medium-voltage applications (2kV to 15kV). Therefore, aging effects related to cable exposed to moisture are not applicable for Oconee insulated cables and connections.

7.5.2.3 Low-Voltage & Medium-Voltage Cable Insulation — Radiation, Oxygen

The following table lists both the *lowest* threshold of gamma radiation and the moderate damage dose for the materials listed in Table 7-4 [Reference 8, Table 4-7, page 4-47; Reference 41], Appendix C]. The threshold value is the amount of radiation that causes incipient to mild damage. Once this threshold is exceeded, damage to the insulation increases from mild—to moderate—to severe as the total dose increases by one to two orders of magnitude (an increase of one million to ten million rads). The moderate damage value indicates the value at which the material has been damaged but is still functional. Additional information regarding specific insulation types is given in the right side column of the table.

Table 7-11
Radiation Dose Data — Insulated Cables & Connections Materials

Material	Lowest Threshold Dose	Moderate Damage Dose	References & Additional Information (Unless Otherwise Noted, Dose Data is From Reference 91, Table 4-7, page 4-47, or Reference 41, Appendix C)
Kapton	1×10^7 rads	2×10^8 rads	
XLP, XLPE, Vulkene, FR-XLPE	1×10^6 rads	1×10^8 rads	
Kerite-HTK	1×10^6 rads	1×10^8 rads	Although no value for Kerite is listed in DOE Cable AMG Table 4-7, the insulation material has been tested many times for the nuclear industry at total doses in excess of 1×10^8 rads [Reference 42]. This value is used as the moderate damage dose and, to be conservative, a threshold value two orders of magnitude less than this is assumed.
EP, EPR, EPDM, FR-EP, FR-EPR	1×10^6 rads	5×10^7 rads	
Phenolic	$\sim 3 \times 10^6$ rads	$\sim 4 \times 10^7$ rads	The radiation resistance of phenolic varies depending on what it is “filled” with (e.g., glass, asbestos, etc.). The values for “unfilled” phenolic are chosen since it is the weakest.
Tefzel®	1×10^7 rads	3×10^7 rads	[Reference 43]
PE	3.8×10^5 rads	2×10^7 rads	
PVC, Vinyl	1×10^5 rads	2×10^7 rads	
Teflon®	1×10^4 rads	5×10^4 rads *	[Reference 41] * Testing by Westinghouse of Teflon® lead wires established that the wire is qualified to 1×10^7 rads. [Reference 44]
Polypropylene	1.2×10^6 rads	5×10^6 rads	[Reference 45]
Butyl	7×10^5 rads	5×10^6 rads	
SR	1×10^6 rads	3×10^6 rads	
Hypalon	5×10^5 rads	2×10^6 rads	
Nylon	5×10^5 rads	2×10^6 rads	There are many formulations of nylon, a material originally developed by the DuPont Co. The values used here are for the most common formulation (general purpose) of nylon, which is referred to as Nylon 66 and is designated Zytel 101. Zytel® is the DuPont trademark for many different nylon resins.
Polyalkene	No data	No data	No data could be obtained for polyalkene. However, the material was tested [Reference 87] and the material is described as “irradiation cross-linked polyalkene” which means that the material is subjected to radiation as part of the manufacturing process (similar to irradiation cross-linked polyethylene, commonly known as XLPE). Since the irradiation process is used to strengthen the material, it is assumed that it has a relatively high resistance to radiation after the manufacturing process.
AVA	None	None	AVA is a code for impregnated asbestos and varnished cambric insulation covered by asbestos braid or glass. Asbestos is a mineral and is not affected by radiation.
Fiberglass	None	None	Fiberglass is spun glass and except for some change in color is not affected by radiation.

Comparing the radiation values given above with the service conditions shown in Table 7-9 indicates that all of the insulation materials can withstand the maximum 60-year normal radiation dose for their installed locations with only possible moderate damage. Aging effects caused by radiation exposure will not adversely affect the intended function of any insulated cables and connections during the current or extended period of operation. Therefore, aging effects related to radiation and oxygen are not applicable for the cables included in the AMR.

7.5.2.4 Low-Voltage & Medium-Voltage Cable Insulation — Heat, Oxygen

The total thermal life of insulated cable and connection materials can be calculated using the Arrhenius method as described in EPRI NP-1558 [Reference 41]. The Arrhenius method is normally used to calculate a thermal life at a given temperature; however, it can be used to calculate a maximum continuous temperature for a specific length of time. Therefore, using the Arrhenius method in this way, with the time period fixed at 60 years, calculations were performed to determine the maximum continuous temperature to which the material can be exposed so that the material will have the indicated "endpoint" at the end of 60 years.

Conservatism in the Thermal Aging Condition "Endpoint"
The typical "endpoint" for cable thermal aging data is 40% to 60% retention-of-elongation. Research funded by the NRC and published in NUREG/CR-6384 [Reference 46, page 5-57] determined that the retention-of-elongation of most cable insulation materials can be reduced to 0% and the insulation will still be capable of withstanding a loss-of-coolant accident (LOCA) and remain functional. As the insulated cables and connections subject to an AMR will either not be subjected to an accident environment or are not required to function after being subjected to an accident environment, the endpoints chosen for this review are extremely conservative. The insulated cable and connection materials can be aged a great deal more, possibly to the point where retention-of-elongation reaches 0%, without loss of intended function.

Preliminary results of the environmental qualification research on low-voltage electrical cables were presented at an NRC public meeting on March 19, 1999. As added indication that there is margin in the thermal aging, preliminary conclusions from LOCA tests 1, 2 and 3 of the NRC research program indicate that, "Electric cables with insulation EAB [elongation-at-break] values as low as 5% performed acceptably under accident conditions." [Reference 47]

Therefore, the useable 60-year life temperature for cable insulation is significantly higher than the values shown in the following table. See Acronyms & Definitions for an explanation of terms used in the table.

Table 7-12
Temperature Data – Insulated Cables And Connection Materials

Insulation	Maximum Temperature for 60-Year Life	Activation Energy (eV)	"b"	60-Year Endpoint	Activation Energy Reference
Teflon®	648°F (342°C)	3.45	-22.56	10% Weight Loss in Vacuum	[41, Citation 537]
SR	273°F (133.9°C)	1.81	-16.69	50% Retention-of-Elongation	[74]
Kapton	248°F (120.0°C)	3.916 [Footnote 6]	-43.208	Failure [Footnote 7]	[48], [49]
Tefzel ®	226°F (108°C)	0.90	-6.16	50% Retention of Elongation	[50]
Phenolic	220°F (104.7°C)	1.37	-12.14	50% Retention of Impact Strength	[41, Citation 1026]
Polyalkene	189°F (87.2°C)	1.11	-9.79	Mean-Time-To-Failure	[4]
XLP, XLPE, Vulkene, FR-XLPE	188°F (86.7°C)	1.35	-13.19	60% Retention-of-Elongation	[51]
Kerite-HTK	185°F (85.2°C)	1.07	-9.33	20% Retention-of-Elongation	[52]
EP, EPR, EPDM, FR-EP, FR-EPR	155°F (68.3°C)	1.10	-10.51	40% Retention-of-Elongation	[53]
Hypalon	154°F (67.8°C)	1.14	-11.13	50% Elongation	[54]
PE	131°F (55.0°C)	1.14	-12.37	T_{75} Induction Period	[55], [56]
Nylon	123°F (54.4°C)	0.84	-7.44	28% Retention of Tensile Strength	[56], [57]
Butyl	125°F (51.7°C)	1.10	-11.34	40% Retention-of-Elongation	[58]
Polypropylene	122°F (50°C)	1.13	-11.90	T_{75} Induction Period	[41, Citation 973]
PVC, Vinyl	112°F (44.4°C)	0.99	-10.00	Mean-Time-To-Failure	[4]
Fiberglass	Does not age from heat.	- - -	- - -	- - -	- - -
AVA	No Data [Footnote 8]	No Data	No Data	No Data	No Data

Comparing the maximum 60-year life temperatures given above to the bounding temperatures identified in Table 7-9 indicates that, except for EP, EPR, EPDM and FR-EPR used in power applications, all of the insulation materials can withstand the bounding temperatures for at least 60 years.

6. **Kapton Activation Energy:** The activation energy stated in IPS-1079 [Reference 48] was obtained from CONAX report IPS-325 [Reference 49], which should be reviewed in detail to understand the basis for the unusually high value of the activation energy.
7. **Kapton Endpoint:** The endpoint "Failure" is from the test report. Actually, what CONAX used was "the midpoint between detection of failure and the last test" [Reference 49, pages A5, A6, A10].
8. **AVA:** A code for impregnated asbestos and varnished cambric insulation covered by asbestos braid or glass. It is rated for a maximum operating temperature of 110°C (230°F) for use in dry locations only. It is an obsolete material that was deleted from the National Electrical Code in 1982 -1983. The only use for it at Oconee is as a special cable shield grounding system.

Therefore, except for EP, EPR, EPDM or FR-EPR insulated cables and connections, aging effects related to heat and oxygen are not applicable for the cables included in the AMR.

EP, EPR, EPDM and FR-EPR insulation materials are discussed in the section below.

7.5.2.4.1 EP, EPR, EPDM, FR-EP & FR-EPR

The bounding service temperature for EP, EPR, EPDM, FR-EP and FR-EPR is 158.45°F (70.25°C). The maximum temperature for a 60-year life is 154.9°F (68.3°C), which is 3.55°F less than the bounding service temperature. This difference is very small and is considered to be within the conservatism’s incorporated into the bounding service temperature, as explained below.

The 60-year life endpoint for EP, EPR, EPDM, FR-EP and FR-EPR is 40% retention-of-elongation. Since the cables and connections subject to an aging management review either will not be subjected to accident conditions or are not required to remain functional during or after an accident, these values can be reduced much further without a loss of function. With a difference of 3.55°F, the actual endpoint at the end of 60 years may be slightly lower than 40% retention-of-elongation but still much more than required for the cable to perform its intended function.

The bounding temperature includes a calculated self-heating temperature rise that assumes normal operation 100% of the time since initial operation. The Oconee units have historically operated less than 75% of the time since initial operation [Reference 59]. This amount of shutdown time lessens the amount of aging actually occurring and thus extends the life of the material.

Given these conservatisms, there is reasonable assurance that EP, EPR, EPDM, FR-EP and FR-EPR insulated cables will not thermally age through extended period of operation to the point that they will not be able to perform their intended function.

7.5.2.4.2 Results — Low-Voltage & Medium-Voltage Cable Insulation — Heat, Oxygen

Aging effects related to heat and oxygen are not applicable for the cables included in the AMR.

7.6 Operating Experience — Insulated Cables & Connections

Operating experience is reviewed in the following sections.

7.6.1 Industry Experience

The DOE Cable AMG [Reference 8, Section 3.7] includes an industry experience review that includes a review of NRC generic communications. The DOE Cable AMG review was used by Duke to identify the potential aging effects for insulated cables and connections.

7.6.2 Oconee Experience

Oconee operating experience was reviewed to identify applicable aging effects for insulated cables and connections. This review included a survey of documented instances of insulated cable or connection in the Problem Investigation Process (PIP) database aging along with interviews of responsible engineering personnel.

During this review, it was recognized that incidents involving insulated cables and connections could be grouped into two sets. Some incidents are clearly design, installation and maintenance related and not relevant to license renewal, while other incidents are clearly aging related and relevant to license renewal. Engineering judgement was used for incidents that fell somewhere between these clear distinctions. The judgement reached was that all insulated cable and connection incidents were design, installation or maintenance related problems, were not aging related and were not relevant to license renewal.

During the NRC license renewal inspections (see NRC Inspection Report 99-12 [Reference 60]), the NRC inspectors expressed their opinion that physical evidence of degradation indicates the need for aging management. NRC Inspection Report 99-12 stated that *"for electrical cables and connections, the inspection team concluded that the potential aging effects of moisture, radiation, and heat identified in the LRA are applicable at ONS. Based on the evidence of aging effects and the team's review of actual plant experience, the team could not agree with the applicant that no aging management review is needed for electrical cables and connectors for the period of extended operation."* The NRC inspector observations were noted. The areas of focus and the inspection team's findings for electrical cables and connectors that support this conclusion were discussed in the inspection report.

What was made evident as a result of the inspections is that the problems focused on by the staff as being aging related were those identified as design or installation problems during the initial operating experience review. What was learned was that design or installation problems that are not fixed to mitigate or eliminate the adverse conditions causing the observed aging effects, become aging problems for license renewal. That is, if the cause of the accelerated aging is not redesigned or fixed so it is eliminated it is still affecting the components and the resulting aging effects need to be managed for license renewal.

Other NRC statements in the areas of connectors exposed to boric acid exposure and medium-voltage cables exposed to moisture do not come from actual observations at Oconee but are reactive to incidents at other plants.

7.7 AMR Conclusion — Insulated Cables & Connections

In most areas at Oconee the actual ambient environments are less severe than the design environments and plant insulated cables and connections are made of materials that will enable them to maintain their intended functions through the extended period of operation. However, based on the Oconee operating experience review as documented in the NRC license renewal inspection report [Reference 60] there a limited number of localized areas where insulated cables and connections have been found to be degrading prematurely; suggesting that the actual environments are more severe than the design environments and that the insulated cables and connections in these areas may not remain functional through the license renewal period if not managed. These adverse, localized environments [Footnote 9] were identified through a PIP search as part of the license renewal inspections and are detailed in Chapter 17. Therefore, in-scope, insulated cables and connections that could be affected by these adverse, localized environments will be included in an aging management program. The basis and details of the aging management program for insulated cables and connections are provided in the following subsections.

7.7.1 Basis of the Insulated Cables & Connections AMP

The basis for the aging management program (AMP) for insulated cables and connections is found in Inspection Report 99-12 [Reference 60] and subsequent correspondence with the NRC [Reference 61]. NRC Inspection Report 99-12 describes several items individually and then lists several PIPs without any descriptions.

7.7.1.1 Process to Identify Applicable Aging Effects

As background, the process used by Duke to identify applicable aging effects is outlined in Section 3.2.1 of Exhibit A of the Application [Reference 62], "Process Overview" and is summarized below:

(1) Identify **potential aging effects** by reviewing available industry literature.

(2) Evaluate potential aging effects to determine which ones are applicable by reviewing:
- (a) **materials of construction** and
- (b) **service environments**.

(3) Provide confidence that the set of applicable aging effects has been identified by reviewing relevant:
- (a) **industry experience,**
- (b) **NRC generic communications** and
- (c) **Oconee experience**.

7.7.1.2 Components the NRC Staff Concluded Have Applicable Aging Effects

An applicable aging effect is an aging effect that could cause the component to lose its intended function before the end of the extended period of operation. This process was accepted for electrical components as discussed in the draft SER [Reference 63 Section 3.9.4], "Conclusions" which is quoted below:

> *"The staff has reviewed the information in Sections 3.2 and 3.6 of Exhibit A of the LRA and the additional information provided by the applicant in response to the staff RAIs. On the basis of this review, the staff concludes that there are no applicable aging effects at the ONS for phase bus, switchyard bus, insulated cables and connections, insulators, and transmission conductors. Therefore, no aging management programs are necessary for these electrical components."*

9. An adverse, localized environment is defined as a condition in a limited plant area that is significantly more severe than the specified service condition for the equipment.

The staff does not make the same conclusion regarding insulated cables and connections. But as stated in the SER the staff agreed that no components other than insulated cables and connections have applicable aging effects and no other component require aging management in the renewal term.

7.7.1.3 Categorizing Oconee Operating Experience Related to Insulated Cables & Connections

The items and PIPs reviewed during the on-site inspection comprise all of the Oconee operating experience as identified in the applicable aging effects identification process.

During the inspection most of the items identified in the inspection report were reviewed and categorized by the NRC inspection team along with Duke personnel. The criteria used to create these categories aligns with the Duke process to scope and screen components and the process that identifies applicable aging effects. Most of the items and PIPs identified in the inspection report were found not to involve problems relevant to the aging management review. The additional items and PIPs not categorized during the inspection have been categorized by Duke using the same criteria. All items and PIPs identified in the inspection report are organized into the following groups:

(1) Those Involving Identification of Cable Insulation Materials

(2) Those Involving Components Other Than Insulated Cables & Connections

(3) Those Involving Insulated Cables & Connections Serving No License Renewal Intended Functions

(4) Those Involving Installation Problems, Maintenance Problems, Equipment Problems and Other Non-Aging Problems

(5) Those Involving Insulated Cables and Connections With No Applicable Aging Effects

(6) Those Involving Insulated Cables and Connections With Applicable Aging Effects

The items and PIPS in each group above are detailed in Chapter 17. Only Group 6 above is relevant for establishing the scope of an aging management program for insulated cables and connections. The different categories of items included in Group 6 are identified in the following separate subsections.

7.7.1.3.1 Insulated Cables & Connections Exposed To Heat

Cables Next To A Feedwater Pipe
Instrumentation cables in a Reactor Building cable tray installed directly over a feedwater line. The heat escaping from the shield wall penetration sleeve around the pipe is accelerating the aging of the cable insulation. A similar configuration exists in the Reactor Building of each unit.

No scoping was performed to determine if these cables perform any license renewal intended functions.

Cables Routed Next To The Steam Generators Or Pressurizers

Instrumentation cables are routed next to a steam generator or a pressurizer. Heat from the steam generator or pressurizer is accelerating the aging of the cable insulation. Instances of this were found in both the Unit 1 and Unit 2 Reactor Buildings. No scoping was performed to determine if these cables perform any license renewal intended functions.

Pressurizer Heater Cable Connectors

Heat-shrink tubing is installed over the cable/connector interface on some pressurizer heater cable connectors. Heat from the pressurizer is accelerating the aging of the heat-shrink tubing. Instances of this were found in both the Unit 1 and Unit 2 Reactor Buildings. The connectors used for the pressurizer heaters controlled from the Standby Shutdown Facility (SSF) are the only pressurizer heater cable connectors within the scope of license renewal. Not all connectors have a heat-shrink covering installed and it was not determined if any SSF heater connectors have heat-shrink covering installed on them.

Conservatism is added to the program in that some of the situations were found only in the Unit 1 and Unit 2 Reactor Buildings and the inspections will be performed for all three units. In addition, accelerated aging is found only in isolated areas around steam generators and pressurizers, but the inspections will expand beyond these specific areas to include all areas around (within 3 feet of) these components. The aging management program will be performed by visual inspections that will be performed at least every 10 years. As the aging effects are relatively slow acting, even when accelerated by higher temperatures, an inspection every 10 years is adequate.

7.7.1.3.2 Connectors Exposed to Borated Water Leakage

NRC Inspection Report 99-12 stated that the inspectors agreed with Duke's conclusion regarding boric acid exposure on insulated cables and connections "*with the exception of potential boric acid ingress into cable connector pins which can result in connector failure….*" There are no Oconee PIPs that prompted this issue. Paul Shemanski, NRC inspector from Washington, had remembered an incident at a plant out west years ago where borated water leaked onto and intruded into a connector where upon the connector pins corroded and the connector failed. Paul combined that incident with (1) the fact that Oconee has periodic borated water leakage, (2) that the pressurizer heater cables are made of Kapton (which have moisture related aging effects) and (3) that many of the pressurizer heater cable connectors are covered with a heat shrink that deteriorates at an accelerated rate and requires maintenance.

To answer this concern, the *Boric Acid Wastage Surveillance Program* will be used to manage connector applicable aging effects associated with exposure to borated water. This program is described in Section 4.5 of Exhibit A of the Application [Reference 62]. The staff review of the *Boric Acid Wastage Surveillance Program* is provided in Section 3.2.1.3 of the Safety Evaluation Report (June 1999) [Reference 63]. Based on its review, the staff concluded that Duke has demonstrated that the *Boric Acid Wastage Surveillance Program* will adequately manage aging effects associated with boric acid wastage for the period of extended operation.

7.7.1.3.3 Medium-Voltage Cable Aging Effects Associated with Moisture and Voltage Stress

Regarding "*moisture/water accumulation in conduits or trenches*", the staff reviewed Duke's assessment of cables aging effects related to moisture and voltage stress and concluded in the SER [Reference 63, Section 3.9.3.1.3] that there are no applicable aging effects. There was only one instance of a failure related to moisture and, per the LER, the cause of the failure was improper installation that allowed water intrusion under the overall cable jacket. This failure occurred less than 9 years after initial operation and no other failures related to moisture have occurred at Oconee. There is no basis in the Oconee operating experience that indicates this is an applicable aging effect for Oconee medium-voltage cable. However, during the time when the Oconee insulated cables and connections aging management program was being formed and reviewed there was a highly visibility failure of a medium-voltage cable at Davis-Besse that was inaccessible and installed in a conduit. This was basically bad timing for Oconee and the staff would not let go of the issue and Duke (and NRC staff) management were all intent on wrapping up the technical work. Therefore, Duke included in the insulated cables and connections aging management program aspects to identify in-scope, medium-voltage cables installed in conduit or direct buried that are exposed to significant voltage and moisture and to monitor water collection in cable manholes containing in-scope, medium-voltage cables.

Medium-voltage cables potentially exposed to moisture are installed in either a conduit, cable trench, installed outside or are direct buried. Medium-voltage power cables installed in a cable trench are supported above the floor of the trench and are not subject to significant moisture. Likewise, medium-voltage cables exposed to outside conditions are not exposed to significant moisture. Therefore, only medium-voltage cables in stalled in conduit or direct buried are potentially exposed to significant moisture and voltage. These are listed in the following table.

Table 7-13
Medium-Voltage Cables Potentially Exposed to Moisture

Description	Circuit Voltage	How Installed	Cable Runs	
			From	To
Keowee Power Cables to Transformer CT4	13.8kV	Direct Buried	Unit 1&2 Switchgear Blockhouse	Keowee Switchgear Vault
Keowee Transformer CX Power Cables from Oconee	4160V	Direct Buried	Unit 1&2 Switchgear Blockhouse	Keowee Powerhouse
Auxiliary Service Water (ASW) Switchgear Cables	4160V	Buried Conduit	Unit 1&2 Switchgear Blockhouse	Oconee Transformer Yard Manholes to Turbine Building to Auxiliary Building
High Pressure Service Water (HPSW) Pumps A & B Cables	4160V	Buried Conduit	Unit 1&2 Switchgear Blockhouse	Oconee Transformer Yard Manholes to Turbine Building
Auxiliary Power System Power Cables to Switchgear B3T & B4T	4160V	Direct Buried, Cable Trench	230kV Switchyard	Oconee Transformer Yard
Auxiliary Power System Power Cables to loads from Switchgear B3T and B4T including: • Radwaste Facility • Interim Radwaste Facility • Load Center SLXOD • Reactor Coolant Pump Refurbishment Building	4160V	Cable Trench, Buried Conduit, Outside ambient	Oconee Transformer Yard	• Turbine Building • Radwaste Facility • Interim Radwaste Facility • Reactor Coolant Pump Refurbishment Building

The Auxiliary Power System power cables feed Switchgear B3T and B4T which are located in the Oconee Transformer Yard and feed loads from these switchgear which include the loads identified in the Table 7-13. The equipment pads supporting these switchgear and the identified facilities, load center and building fed from these switchgear are not within license renewal scope [References 30, 12]. Therefore, the 4160V cables feeding and fed from these switchgear are not within license renewal scope.

The remaining in-scope insulated cables are sorted by exposure area in the following table.

Table 7-14
Potential Moisture Exposure — In-Scope Medium-Voltage Cables

How Installed	Description	Circuit Voltage
Direct Buried	Keowee Power Cables to Transformer CT4	13.8kV
	Keowee Transformer CX Power Cables from Oconee	4160V
Buried Conduit	ASW Switchgear Cables	4160V
	HPSW Pumps A & B Cables	4160V

Each of the cables above should be reviewed to determine if they meet the significant moisture and significant voltage exposure definition or are designed for the conditions to which they are exposed.

7.7.1.3.4 Monitoring Service Environments (Not Included In The Program)

SER Open Item 3.9.3-1 [Reference 64, Comment 4] stated something that should be incorporated into the program was, "*Periodic monitoring of service environments of cables and connections for radiation or temperature hot spots or moisture/water accumulation in conduits or trenches.*" Service environments of cables and connections need not be periodically monitored for radiation or thermal hot spots. Hot spots are adverse, localized environments which by their very nature exist because of (a) inadequate initial design, (b) invalid design assumptions, (c) a change in the operating modes of the plant, (d) modifications to plant systems or equipment or (e) improper maintenance. The most comprehensive industry document on the identification and treatment of adverse, localized, equipment environments such as thermal and radiation hot spots is the 1999 EPRI report TR-109619. Duke personnel participated in the development of this document and Duke will use it as guidance in implementing this program. This report emphasizes visual inspection walkdowns as the primary method for identifying adverse, localized environments and states, "*The basic walkdown guidance presented in Appendix A can successfully identify adverse localized environments and their effects ... as these adverse environments are identified, they are managed by such activities as periodic replacement, relocation of the cable, addition of thermal insulation, or improvements to HVAC.*" Therefore, Duke will use visual inspections instead of periodic monitoring of service environments for identifying thermal and radiation hot spots.

7.7.2 Attributes of the Insulated Cables & Connections Aging Management Program

The aging management program for the insulated cables and connections at Oconee is described below [Reference 65] using the program attributes described in Section 4.2 of Exhibit A of the Application [Reference 62].

INSULATED CABLES & CONNECTIONS AGING MANAGEMENT PROGRAM

Purpose

The purpose of the *Insulated Cables and Connections Aging Management Program* is to provide reasonable assurance that the license renewal intended functions of insulated cables and connections will be maintained consistent with the current licensing basis through the period of extended operation.

Scope

The *Insulated Cables and Connections Aging Management Program* includes accessible and inaccessible insulated cables within the scope of license renewal that are installed in adverse, localized environments in the Reactor Buildings, Auxiliary Buildings, Turbine Buildings, Standby Shutdown Facility, Keowee, in conduit and direct-buried, which could be subject to applicable aging effects from heat, radiation or moisture. This program does not include insulated cables and connections that are in the Environmental Qualification program. An adverse, localized environment is defined as a condition in a limited plant area that is significantly more severe than the specified service condition for the equipment. An applicable aging effect is an aging effect that, if left unmanaged, could result in the loss of a component's license renewal intended function in the period of extended operation.

Aging Effects

Change in material properties of the conductor insulation is the applicable aging effect. The changes in material properties managed by this program are those caused by severe heat, radiation or moisture — conditions that establish an adverse, localized environment, which include energized medium-voltage cables exposed to significant moisture.

Method

The methods used are different for accessible insulated cables and connections and for inaccessible or direct-buried medium-voltage cables, which cannot be visually inspected.

Accessible insulated cables and connections installed in adverse, localized environments will be visually inspected for jacket surface anomalies such as embrittlement, discoloration, cracking or surface contamination. Surface anomalies are indications that can be visually monitored to preclude the conductor insulation applicable aging effect. In addition, water collection in manholes containing in-scope, medium-voltage cables will be monitored to prevent the cables from being exposed to significant moisture.

NOTE: Monitoring water in manholes in a preventive action. Another preventive action would be to identify the medium-voltage cables possibly subject to testing and ensure that they are not exposed to moisture (e.g., ensure their conduits are dry).

Inaccessible or direct-buried, medium-voltage cables exposed to significant moisture and significant voltage will be tested. The specific type of test performed will be determined prior to each test. Significant moisture exposure is defined as periodic exposures to moisture that last more than a few days (e.g., cable in standing water). Periodic exposures to moisture that last less than a few days (i.e., normal rain and drain) are not significant. Significant voltage exposure is defined as being subjected to system voltage for more than twenty-five percent of the time. The moisture and voltage exposures described as significant in these definitions are not significant for medium-voltage cables that are designed for these conditions.

NOTE: The type of test for medium-voltage cables is not specified. Any type of test can be chosen that will provide confidence in the ability of the cable to perform its function. Only in-scope medium-voltage cables meeting the criteria–exposed to significant moisture and significant voltage or not designed for these exposures–are required to be tested.

Sample Size

Samples may be used for this program. If used, an appropriate sample size will be determined prior to the inspection or test.

NOTE: Although not explicit, the inspection program covers both accessible and inaccessible cables in that if an unacceptable condition or situation is identified for an accessible cable, a determination will be made as to whether this same condition or situation could be applicable to other inaccessible cables. In this view, the inspection program is like a sampling program. Inaccessible insulated cables and connections in adverse localized environments are covered indirectly by the program.

Industry Codes and Standards

EPRI TR-109619, *Guideline for the Management of Adverse Localized Equipment Environments* will be used as guidance in implementing this program.

Frequency

Accessible insulated cables and connections installed in adverse, localized environments will be inspected at least once every 10 years. Water collection in manholes containing in-scope, medium-voltage cables will be monitored at a frequency adequate to prevent the cables from being exposed to significant moisture.

Inaccessible or direct-buried, medium-voltage cables exposed to significant moisture and significant voltage will be tested at least once every 10 years.

Acceptance Criteria or Standard

The acceptance criteria is different for accessible insulated cables and connections and for inaccessible or direct-buried medium-voltage cables.

For accessible insulated cables and connections installed in adverse, localized environments, the acceptance criteria is no unacceptable, visual indications of jacket surface anomalies, which suggest that conductor insulation applicable aging effect may exist, as determined by engineering evaluation. An unacceptable indication is defined as a noted condition or situation that, if left unmanaged, could lead to a loss of the license renewal intended function. In-scope, medium-voltage cables in manholes found to be exposed to significant moisture will be tested as described for inaccessible cables under Method, Frequency and Acceptance Criteria of this program.

For inaccessible or direct-buried, medium-voltage cables exposed to significant moisture and significant voltage, the acceptance criteria for the test will be defined by the specific type of test to be performed and the specific cable to be tested.

Corrective Action
Further investigation by engineering will be performed on accessible and inaccessible insulated cables and connections when the acceptance criteria is not met in order to ensure that the license renewal intended functions will be maintained consistent with the current licensing basis. Corrective actions may include, but are not limited to, testing, shielding or otherwise changing the environment, relocating or replacement. Specific corrective actions will be implemented in accordance with the Problem Investigation Process. The Problem Investigation Process applies to all structures and components within the scope of the *Insulated Cables and Connections Aging Management Program*. When an unacceptable condition or situation is identified, a determination will be made as to whether this same condition or situation could be applicable to other accessible or inaccessible cables and connections.

Timing of New Program or Activity
Following issuance of a renewed operating licenses for Oconee Nuclear Station, the initial inspections and tests will be completed by February 6, 2013 (the end of the initial license term for Oconee Unit 1).

Regulatory Basis
Duke response to SER Open Item 3.9.3 [Reference 66] and Final SER [Reference 67].

8
INSULATORS

This chapter continues the electrical integrated plant assessment (IPA) by reviewing insulators. All remaining electrical IPA work related to insulators installed at Oconee is documented in this chapter. The process outlined in Figure 1-1 is followed in this chapter for insulators.

General Description

An insulator is an insulating material in a form designed to (a) support a conductor physically and (b) separate the conductor electrically from another conductor or object [Reference 17]. The insulators evaluated in this chapter are those used to support uninsulated, high voltage electrical components such as conductors and bus. These insulators are large and were purchased as separate electrical system components. Two basic types of insulators are installed at Oconee: station post insulators and strain or suspension insulators.

Station post insulators are large and rigid. They are used to support stationary equipment such as electrical bus. Multiple station post insulators can be fastened together (end to end) to increase the electrical separation between the electrical component and the supporting structure.

Strain and suspension insulators are smaller than station post insulators and are constructed in a way that allows them to be strung together; different string lengths for different separation requirements. They are used in applications where movement of the supported conductor is expected and allowed. Strain and suspension insulators are the same insulators; the difference in name is due to their application. Strain insulators are used to maintain tensional support for a transmission conductor between transmission towers or other supporting structures. Suspension insulators normally hang in a vertical position, maintain the conductor spacing from other objects and are normally under only tension due to the gravity load of the supported conductor and the other insulators in the string.

8.1 List — Insulators

Chapter 3 concluded that insulators associated with the 525kV Switchyard, the Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines and the Oconee 44kV Retail substation do not meet the criteria of §54.4(a). Therefore, an encompassing group (as described in Section 1.2) of insulators, except those (1) associated with the 525kV Switchyard, (2) associated with the Jocassee, Calhoun, Oconee or Dacus 230kV transmission lines or (3) associated with the Oconee 44kV Retail substation, is included in the AMR.

Plant walkdowns of outside areas containing high voltage electrical components identified electrical components supported by insulators, which are listed below.

- **Switchyard Bus:** Rigid, round bus used in a switchyard or switching station.

- **Transmission Conductors:** Flexible, uninsulated electrical cables used to connect plant transformers to a switchyard (referred to as bus lines), connect various electrical components within a switchyard or switching station and connect different switchyards and switching stations in a transmission network.

Typical insulator installations are shown on switchyard layout drawings

From the electrical component descriptions above, a list of insulators included in the AMR is generated which is the list presented in the following table. A diagram of the 230kV Switchyard is provided following the table.

Table 8-1
Included In The AMR — Insulators

Description
Insulators supporting bus and conductors in the 230kV Switchyard
Insulators supporting conductors in the Keowee 230kV Transformer Yard
Insulators supporting 230kV conductors in the Oconee Transformer Yard
Insulators supporting the Keowee 230kV Transmission Line
Insulators supporting the 100kV Fant Black Line
Insulators supporting bus and conductors in the 100kV Switching Station

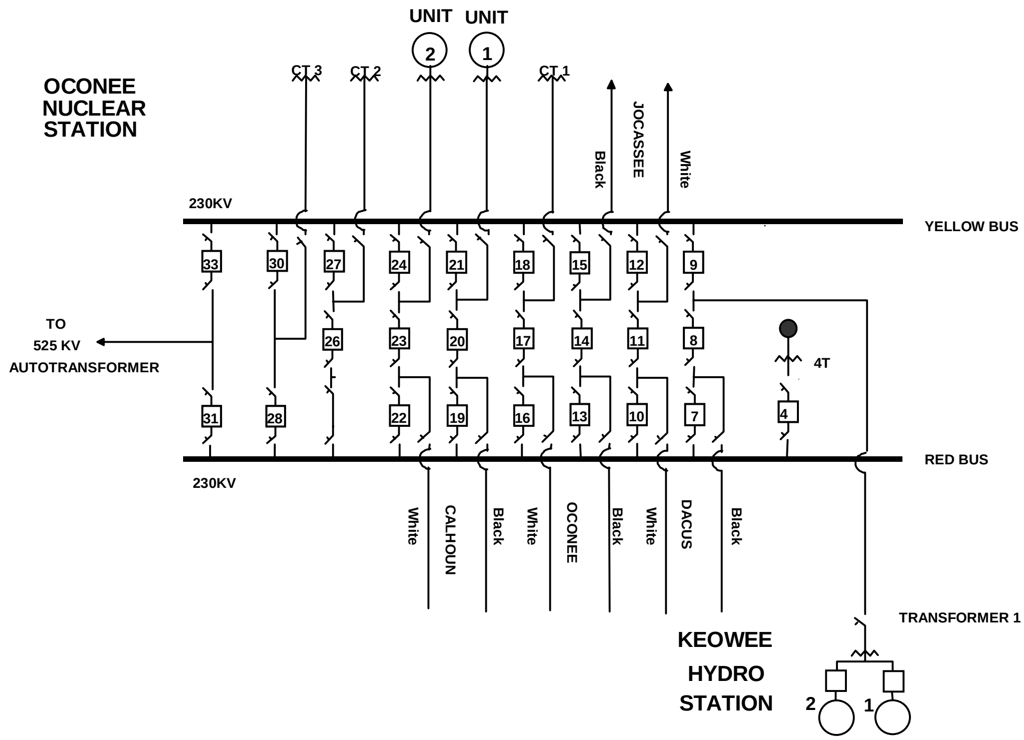

Figure 8-1
Oconee 230kV Switchyard One-Line Diagram

8.2 Component Boundaries — Insulators

Station post, strain and suspension insulators are always supported from a structure such as a transmission tower or support pedestal. The insulators serve as an intermediate component between the supporting structure and the switchyard bus or transmission conductor. Switchyard bus and transmission conductors are secured to insulators using specifically designed hardware.

Structural steel supports and connecting hardware are reviewed in the structures and structural components AMR specification for license renewal [Reference 30]. Transmission conductors and connecting hardware is reviewed in Chapter 13. Switchyard bus and connecting hardware is reviewed in Chapter 12. Therefore, the insulator component boundaries include only the insulator itself.

8.3 Materials — Insulators

Station post, strain and suspension insulators are all constructed of the same basic materials. These materials are shown in the two insulator figures below and are described in Table 8-2.

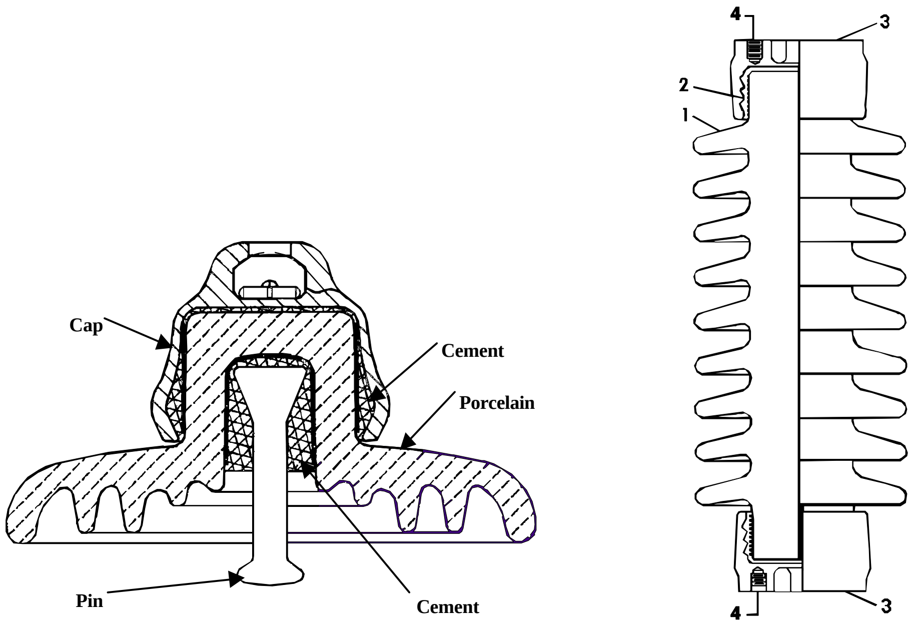

Figure 8-2
Cross Section Of A Typical Strain /Suspension & Post Insulator

Table 8-2
Materials — Insulators

Materials	Description
Porcelain	A hard, white, nonporous translucent variety of ceramic made of kaolin, feldspar and quartz or flint. All exposed porcelain parts are covered with an oven-baked glaze. The color of the glaze is variable; Oconee insulators are gray. The porcelain is the part of the insulator that gives it the insulating qualities. Insulator shape and thickness are major factors in this insulating ability.
Metal	The metal parts of an insulator include the cap (covers both ends of the porcelain on a station post insulator and just one end of the porcelain on a strain or suspension insulator) and the pin (connects the bottom of one strain or suspension insulator to the top or cap of another strain or suspension insulator to form a string). A stainless steel clip is used to hold the pin of one insulator in the cap of the next insulator to form a string. The caps and pins are constructed of various galvanized metals such as malleable iron, ductile iron and drop-forged steel.
Cement	Cement is used as filler for mechanically jointing the porcelain with the caps and pins. A high quality Portland cement is used.

8.4 Service Conditions — Insulators

The two aspects of service conditions—environmental conditions and self-heating temperature rise— are discussed below in separate sections.

8.4.1 Environmental Conditions

Insulators are installed in areas exposed to outside ambient conditions. Reviewing the environmental condition data included in Chapter 15 for thermal environments (Table A-2), radiation environments (Table A-3) and moisture environments (Table A-4) gives the insulator environmental conditions in the following table.

Table 8-3
Environmental Conditions — Insulators

Stressor	Bounding Value
Temperature	105°F (40.6°C)
Radiation	Negligible
Moisture	Precipitation

8.4.2 Self-Heating Temperature Rise

Insulators are subject to self-heating temperature rise where they are fastened against a bus or transmission conductor. Section 13.4.2 gives information relating to self-heating temperature rise for transmission conductors. That same information is applied in this section to insulators. As with transmission conductors, the self-heating temperature rise identified for switchyard bus is applied to insulators.

Table 8-4
Self-Heating Temperature Rise — Insulators

Application	Self-Heating Temperature Rise
All insulators included in the AMR	30°C

8.4.3 Results — Service Conditions

Service conditions for insulators are obtained by combining the environmental conditions information given in Table 8-3 with the self-heating temperature rise information given in Table 8-4. The results are presented in the following table.

Table 8-5
Service Conditions — Insulators

Stressor	Application	Bounding Value
Temperature	All insulators included in the AMR	159.1°F (70.6°C)
Radiation	All insulators included in the AMR	Negligible
Moisture	All insulators included in the AMR	Precipitation

8.5 Aging Effects — Insulators

Potential aging effects for insulators are:

- Surface contamination
- Cracking
- Loss of material due to wear

Each of these is described and assessed in the following sections.

8.5.1 Surface Contamination Assessment

Various airborne materials such as dust, salt and industrial effluents can contaminate insulator surfaces. The buildup of surface contamination is gradual and in most areas such contamination is washed away by rain; the glazed insulator surface aids this contamination removal. A large buildup of contamination enables the conductor voltage to track along the surface more easily and can lead to insulator flashover.

Surface contamination can be a problem in areas where there are greater concentrations of airborne particles such as near facilities that discharge soot or near the sea coast where salt spray is prevalent. Oconee is located in a mountainous area with moderate rainfall where airborne particle concentrations are comparatively low. Consequently, the rate of contamination buildup on the insulators is not significant. At Oconee, as in most areas of the Duke Power transmission system, contamination build-up on insulators is not a problem [Reference 68]. Therefore, surface contamination is not an applicable aging effect for the insulators in the service conditions they are exposed to at Oconee.

8.5.2 Cracking Assessment

Porcelain is essentially a hardened, opaque glass. As with any glass, if subjected to enough force it will crack or break. The most common cause for cracking or breaking of an insulator is being struck by an object (e.g., a rock or bullet). Cracking and breaking caused by physical damage is not an aging effect and is not subject to an AMR.

Cracks have also been known to occur with insulators when the cement that binds the parts together expands enough to crack the porcelain. This phenomenon, know as cement growth, is caused by improper manufacturing process or materials which make the cement more susceptible to moisture penetration. Porcelain cracking caused by cement growth has occurred only in isolated bad batches of insulators used in strain applications. [Footnote 10] The dates of manufacturer and brands of these problem insulators are known. Under Oconee PIP 0-O94-0335, strain insulators used in the start-up transformer bus lines and Keowee 230kV transmission line were inspected. These insulators match those included in the AMR as identified in Table 8-1. The inspections showed that none of the insulators are from the bad batch. This is the only known case of failures related to cement aging [Reference 69].

Cement growth is only an applicable aging effect for specific insulators used in strain applications. No such insulators are included in the AMR. Therefore, cracking due to cement growth is not an applicable aging effect for the insulators included in the AMR.

8.5.3 Loss Of Material Due To Wear Assessment

Mechanical wear is an aging effect for strain and suspension insulators in that they are subject to movement. Movement of the insulators can be caused by wind blowing the supported transmission conductor, causing it to swing from side to side. If this swinging is frequent enough, it could cause wear in the metal contact points of the insulator string and between an insulator and the supporting hardware. Although this mechanism is possible, experience has shown that the transmission conductors do not normally swing and that when they do, due to a substantial wind, do not continue to swing for very long once the wind has subsided. Wear has not been identified during routine inspections of the Oconee insulators. Although rare, surface rust may form where galvanizing is burnt off due to flashover from lightning strikes [References 68, 70]. Surface rust is not a significant concern and would not cause a loss of intended function if left unmanaged for the extended period of operation. Loss of material due to wear will not cause a loss of intended function of the insulators at Oconee. Therefore, loss of material due to wear is not an applicable aging effect for insulators.

10. **Bad Batch:** The manufacture of porcelain insulators is a very precise and controlled process. Manufacturing process changes are documented and the manufacturer and date of manufacture of the insulator parts are identified on the insulator parts. Insulator problems, other than from physical damage, have occurred due to specific manufacturing materials or process problems. If problems are later noted with an insulator, the manufacturer, date of manufacture, and manufacture process information is used to identify other insulators that may exhibit the same problems due to being manufactured during the same time as the insulator with the problem. This is referred to as a bad batch. Insulators manufactured during the period when a materials or process problem existed would be part of this bad batch.

8.6 Operating Experience — Insulators

Operating experience is reviewed in the following sections.

8.6.1 Industry Experience

In order to identify aging effects considered and to assure no additional aging effects exist beyond those discussed herein, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee and NRC NUREGs. The following document related to insulators was identified in this survey:

- IN 93-95, Storm-Related Loss of Offsite Power Events Due to Salt Buildup on Switchyard Insulators

No unique aging effects were identified in the above documents beyond those identified in this chapter.

8.6.2 Oconee Experience

Oconee operating experience was reviewed to identify applicable aging effects for high voltage insulators. This review included a survey of documented instances of component aging along with interviews of responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this chapter.

8.7 AMR Conclusion — Insulators

Based on the review of industry information, NRC generic communications and Oconee operating experience, no aging effects are applicable for insulators subject to an AMR for the extended period of operation. Therefore, no aging management is necessary.

9
ISOLATED-PHASE BUS

This section continues the electrical integrated plant assessment (IPA) by reviewing electrical isolated-phase bus. All remaining electrical IPA work related to isolated-phase bus installed at Oconee is documented in this section. The process outlined in Figure 1-1 is followed in this section for isolated-phase bus.

General Description
An isolated-phase bus is an electrical bus in which each phase conductor is enclosed by an individual metal housing separated from adjacent conductor housings by an air space [Reference 17].

Isolated-phase bus structural supports are reviewed in the structures and structural component AMR for license renewal [Reference 30].

9.1 List — Isolated-Phase Bus

No isolated-phase bus is excluded from the AMR in Chapters 3, 4 or 5. Therefore, an encompassing group (as described in Section 1.2) of all isolated-phase bus is included in the AMR.

Plant walkdowns along with Oconee and Keowee one-line drawings were used to locate all Oconee and Keowee isolated-phase bus. The complete list is given in the following table along with the plant locations where it is installed.

Table 9-1
Included in the AMR•Isolated-Phase Bus

Description	Installed Locations
All sections of Keowee Unit 1 Isolated-Phase Bus	Keowee Structures Keowee Transformer Yard
All sections of Keowee Unit 2 Isolated-Phase Bus	Keowee Structures Keowee Transformer Yard
All sections of Oconee Unit 1 Isolated-Phase Bus	Turbine Building Oconee Transformer Yard
All sections of Oconee Unit 2 Isolated-Phase Bus	Turbine Building Oconee Transformer Yard
All sections of Oconee Unit 3 Isolated-Phase Bus	Turbine Building Oconee Transformer Yard

9.2 Component Boundaries — Isolated-Phase Bus

Isolated-phase bus connects two elements (electrical equipment; e.g., generator, transformer) of an electrical circuit. The point where an isolated-phase bus enters an enclosure and the bus connects to the equipment (and all parts within the enclosure) are considered part of the electrical equipment. This boundary is justified since equipment connection enclosures are inspected and maintained as part of the equipment. Isolated-phase bus structural supports are reviewed in the structures and structural component AMR for license renewal [Reference 30]. Therefore, the evaluation of isolated-phase bus includes only the bus sections and not bus supports of the bus connections to other electrical equipment.

9.3 Materials — Isolated-Phase Bus

The figure below is a cross-section of a typical part of the isolated-phase bus showing the bus assembly, bus support assembly and enclosure assembly as shown on manufacturers drawings.

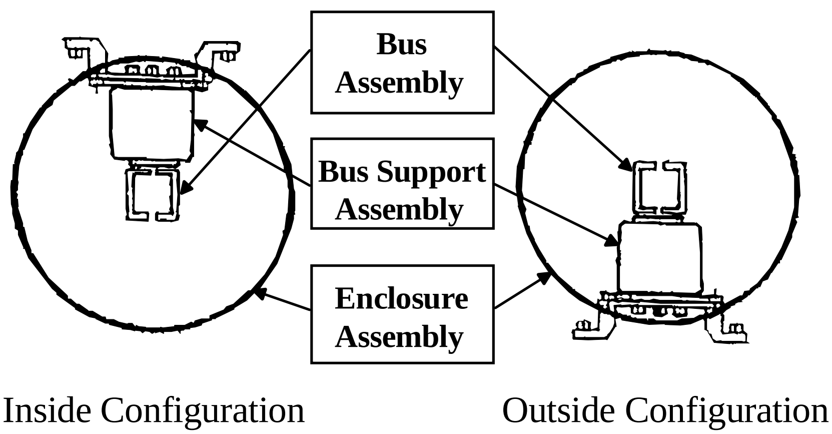

Figure 9-1
Cross Section of Typical Isolated-Phase Bus

As a convenience to identify the materials that make up isolated-phase bus, the bus is separated into definable parts. These parts are listed below and then described in following sections.

- bus assembly
- bus support assembly
- enclosure assembly
- baffle bushing assembly

Parts and materials information is from Oconee and Keowee manufacturer drawings and from Duke personnel that have inspected the bus [Reference 71].]

9.3.1 Bus Assembly

The bus assembly is the electrical conductor for the bus. The main portion of the bus is constructed with channel aluminum, aluminum spacers, aluminum or copper flexible connectors and bronze or stainless steel bolts/washers/nuts. The channel aluminum bus is used for the straight sections of bus. The spacers are used to maintain spacing of the two halves of the bus. The flexible connectors are used to connect bus sections together, bus sections to other components and the bus to the baffle bushing assemblies. The bolts/washers/nuts are used to fasten all these parts together. Grease is used on all bolted aluminum electrical connections to prevent the formation of aluminum oxide on connection surfaces. Grease is a consumable that is replaced during each routine maintenance of the bus and is not reviewed. The bus assembly materials reviewed are:

- aluminum (bus, solid and flexible connectors)
- bronze (bolts/washers/nuts)
- copper (flexible connectors)
- stainless steel (bolts/washers/nuts)

9.3.2 Bus Support Assembly

The bus support assembly supports the bus conductor and insulates it from the enclosure. It is composed of a metal cap (made of various galvanized metals such as malleable iron, ductile iron and drop-forged steel) attached to both ends of a porcelain insulator. The porcelain insulator is smaller but similar to the post insulator shown in Figure 8-2. The insulator is supported by an aluminum mounting bar and support foot. Steel bolts/washers/nuts are used to fasten these parts together. The bus support assembly materials reviewed are:

- aluminum (mounting bar, support foot)
- galvanized metals (insulator caps)
- porcelain (insulator)
- steel (bolts/washers/nuts)

9.3.3 Enclosure Assembly

The enclosure assembly is used to enclose all sections of the bus. The enclosures are constructed of aluminum and fastened in place using aluminum clamps and steel screws. Portions of the enclosure are removable and serve as inspection ports. A cork/neoprene gasket provides a seal around the edge of the removable portion of the enclosure. The gasket is a consumable that is inspected and replaced as needed during each routine maintenance of the bus and is not reviewed. There are laminated aluminum ground straps used to provide continuous ground connections across the removable portions of the enclosure. The ground straps are fastened to the enclosure with steel bolts. Grease is used on the ground strap bolted electrical connections to prevent the formation of aluminum oxide on connection surfaces. Grease is a consumable that is replaced during each routine maintenance of the bus and is not reviewed. The enclosure assembly materials reviewed are:

- aluminum (covers, clamps, ground straps)
- steel (clamp screws, ground strap bolts)

9.3.4 Baffle Bushing Assembly

Baffle bushing assemblies are installed where the bus passes through the Keowee Powerhouse wall. The purpose of the baffle bushing assemblies is to provide a thermal barrier as the bus passes through an outside wall to prevent condensation. The baffle bushing assembly is channel aluminum bus passing through the middle of a porcelain bushing, which is held in place at the wall. The space between the bushing and channel bus is potted with silicone caulk (Dow Corning 3110). The bushing is held in place with grout and a brass bushing mount attached to an aluminum collar/wall plate. The collars have Teflon buttons and are held to the wall with steel bolts/washers/nuts. The Teflon buttons aid in assembly and disassembly of the baffle bushing assembly, play no part in the function of the bus and are not reviewed. There is a cork/neoprene gasket between the wall plate and the wall, which is a consumable part and is not reviewed. The baffle bushing assembly materials reviewed are:

- aluminum (bus, collar/wall plate)
- brass (bushing mount)
- grout (between bushing and bushing mount)
- porcelain (bushing)
- silicone caulk (between the bus and the bushing)
- steel (bolts/washers/nuts)

9.3.5 Results — Materials

The isolated-phase bus materials reviewed as described above are listed in the following table.

Table 9-2
Materials Reviewed — Isolated-Phase Bus

Materials Reviewed	Part of Bus Where Material Is Used			
	Bus Assembly	**Bus Support Assembly**	**Enclosure Assembly**	**Baffle Bushing Assembly**
Aluminum	bus, solid and flexible connectors	mounting bar, support foot	covers, clamps, ground straps	bus, wall plate and collar
Brass				bushing mount
Bronze	bolts, washers, nuts			
Copper	flexible connectors			
Galvanized Metals		insulator caps		
Grout				between bushing and bushing mount
Porcelain		insulator		bushing
Silicone Caulk				between the bus and the bushing
Stainless Steel	bolts, washers, nuts			
Steel		bolts, washers, nuts	clamp screws, ground strap bolts	bolts, washers, nuts

9.4 Environmental Conditions — Isolated-Phase Bus

Isolated-phase bus is installed in the locations identified in Table 9-1. Reviewing the environmental condition data included in Chapter 15 for thermal environments (Table A-2), radiation environments (Table A-3) and moisture environments (Table A-4) gives the stressor bounding value in the following table. Temperature and radiation apply to all parts of the bus whereas moisture applies only to bus assemblies that are outside and exposed to precipitation. This table outlines the isolated-phase bus environmental conditions.

Table 9-3
Environmental Conditions — Isolated-Phase Bus

Stressor	Part of Bus	Bounding Value
Temperature	All	105°F (40.6°C)
Radiation	All	Less than 1.5 x 10^3 rads
Moisture	Parts exposed to outside environment: • Bus Support Assembly - aluminum support foot - steel bolts, washers, nuts • Enclosure Assembly - aluminum covers, clamps, ground straps - steel clamp screws, ground strap bolts • Baffle Bushing Assembly - aluminum wall plate and collar - steel bolts, washers, nuts	Precipitation

9.4.1 Self-Heating Temperature Rise — Isolated-Phase Bus

Self-heating temperature rise of a bus is discussed in detail in Section 10.4.2. The conclusion of that discussion is that the parts of the bus close to or part of the conductor will be exposed to a maximum self-heating temperature rise of 40°C above ambient and the other parts of the bus will have a self-heating temperature rise of 15°C above ambient. These values are used for both the Oconee and Keowee isolated-phase bus. These values are considered representative or conservative for Oconee isolated-phase bus.

These are highly conservative values for long-term aging of the Keowee isolated-phase bus given that each Keowee generating unit has operated (and each isolated-phase bus has carried current) less than 7% of the time [Reference 72]. When not carrying current from Keowee unit generator, the internal power loads of one Keowee unit are back-fed through the main step-up transformer. The internal power loads of one unit are normally less than 1 MW [Reference 73]. Since each Keowee unit is capable of generating 87.5 MVA, the self-heating temperature rise from 1 MW is not significant.

The self-heating temperature rise for the different parts of the isolated-phase bus is shown in the following table.

Table 9-4
Self-Heating Temperature Rise — Isolated-Phase Bus

Part of Bus	Self-Heating Temperature Rise
Bus parts close to or part of the conductor: • Bus Assembly - aluminum bus, solid and flexible connectors - bronze bolts, washers, nuts - copper flexible connectors - stainless steel bolts, washers, nuts • Bus Support Assembly - galvanized metal insulator caps - porcelain insulator • Baffle Bushing Assembly - aluminum bus - porcelain bushing - silicone caulk between the bus and the bushing	40°C
Bus parts not close to or part of the conductor: • Bus Support Assembly - aluminum mounting bar, support foot - steel bolts, washers, nuts • Enclosure Assembly - aluminum covers, clamps, ground straps - steel clamp screws, ground strap bolts • Baffle Bushing Assembly - aluminum wall plate and collar - brass bushing mount - grout between bushing and bushing mount - steel bolts, washers, nuts	15°C

9.4.2 Results — Service Conditions

Service conditions for isolated-phase bus are obtained by combining the environmental conditions information given in Table 9-3 with the self-heating temperature rise information given in Table 9-4. The results are presented in the following table.

Table 9-5
Service Conditions — Isolated-Phase Bus

Stressor	Part of Bus	Bounding Value
Temperature	Bus parts close to or part of the conductor: • Bus Assembly - aluminum bus, solid and flexible connectors - bronze bolts, washers, nuts - copper flexible connectors - stainless steel bolts, washers, nuts • Bus Support Assembly - galvanized metal insulator caps - porcelain insulator • Baffle Bushing Assembly - aluminum bus - porcelain bushing - silicone caulk between the bus and the bushing	177°F (80.6°C)
	Bus parts not close to or part of the conductor: • Bus Support Assembly - aluminum mounting bar, support foot - steel bolts, washers, nuts • Enclosure Assembly - aluminum covers, clamps, ground straps - steel clamp screws, ground strap bolts • Baffle Bushing Assembly - aluminum wall plate and collar - brass bushing mount - grout between bushing and bushing mount - steel bolts, washers, nuts	132°F (55.6°C)
Radiation	All	Less than 1×10^3 rads
Moisture	Parts exposed to outside environment: • Bus Support Assembly - aluminum support foot - steel bolts, washers, nuts • Enclosure Assembly - aluminum covers, clamps, ground straps - steel clamp screws, ground strap bolts • Baffle Bushing Assembly - aluminum wall plate and collar - steel bolts, washers, nuts	Precipitation

9.5 Aging Effects — Isolated-Phase Bus

The potential aging effects for isolated-phase bus are listed in the following table.

Table 9-6
Potential Aging Effects — Isolated-Phase Bus

Material	Stressor Or Mechanism	Potential Aging Effect
Aluminum (bus, solid and flexible connectors and ground straps)	Connection surface oxidation	Change in material properties leading to increased resistance and heating
Silicone caulk	Temperature Radiation	Change in material properties leading to loss of maintained spacing between the bus and bushing
Steel (bolts, washers, nuts and clamp screws)	Precipitation	Change in material properties (corrosion) leading to loss of function for the part
Rigid bus parts	Vibration	Cracking

The applicability of these aging effects is assessed in the following sections.

9.5.1 Aluminum Bus, Solid And Flexible Connectors and Ground Straps — Connection Surface Oxidation

Aluminum is highly conductive but does not make a good contact surface since pure aluminum exposed to air forms aluminum oxide on the surface, which is nonconductive. To prevent the formation of aluminum oxide on connection surfaces, the connections are cleaned with a wire brush (to remove any existing aluminum oxide) and covered with grease to prevent air from contacting the aluminum surface. The grease precludes oxidation of the aluminum surface thereby maintaining good conductivity at the bus connections. The grease is a consumable that is replaced during each routine maintenance of the bus. The frequency of the grease replacement is adequate since no degradation of the grease has been noted during routine maintenance [Reference 71]. Therefore, there are no applicable aging effects for the aluminum bus, solid and flexible connectors and ground straps when exposed to their service conditions for the extended period of operation.

9.5.2 Silicone Caulk — Temperature

The silicone caulk is Dow Corning Silastic 3110, which is a white, room temperature vulcanizing (RTV), silicone rubber encapsulant. It is rated as having a useful upper temperature of 200°C (392°F). Dow Corning cannot provide Arrhenius data for this specific RTV; however, it is silicone rubber and its use temperature is consistent with other silicone rubbers which would imply the following thermal life data [Reference 74]:

- 177.1°F (80.6°C) service temperature = life much greater than 60 years
- 273°F (133.9°C) service temperature = 60-year life maximum temperature

The 60-year life maximum temperature is much greater than the service temperature to which the silicone caulk is exposed. Therefore, there are no applicable aging effects for the silicone caulk when exposed to their service temperature for the extended period of operation.

9.5.3 Silicone Caulk — Radiation

The silicone caulk is Dow Corning Silastic 3110, a white, room temperature vulcanizing (RTV), silicone rubber encapsulant. The lowest reported threshold radiation dose of silicone rubber is 1×10^6 rads [Reference 8, Table 4-7, page 4-47]. Comparing this value to the value given in Table 9-5, the radiation dose is well below the lowest reported threshold radiation dose for silicone rubber. Therefore, there are no applicable aging effects for the silicone caulk when exposed to these service conditions for the extended period of operation.

9.5.4 Steel Bolts, Washers, Nuts and Clamp Screws — Precipitation

Steel hardware (bolts, washers, nuts and clamp screws) exposed to outside weather and precipitation was factory coated to inhibit corrosion. After more than 20 years in its service environment, no signs of corrosion or loss of material have been observed [Reference 71]. Therefore, loss of material for steel hardware is not an applicable aging effect that would lead to a loss of intended function for the phase bus for the period of extended operation.

9.5.5 Rigid Bus Parts — Vibration

Isolated-phase bus is connected to static equipment that does not normally vibrate such as switchgear, transformers and disconnect switches. Isolated-phase bus is supported by static structural components such as cement footings and building steel. Vibration is not an applicable stressor for these connections to non-moving and non-vibrating equipment and supports and aging effects due to vibration are not applicable. Isolated-phase bus, in addition to being connected to static equipment, is connected to the unit generators through flexible conductors. These flexible conductors prevent generator vibrations from propagating into the rigid isolated-phase bus. Therefore, vibration is not an applicable stressor for isolated-phase bus and aging effects due to vibration are not applicable.

9.5.6 Results — Aging Effects

The information given in the sections above is summarized in the following table.

Table 9-7
Applicable Aging Effects — Isolated-Phase Bus

Material	Stressor Or Mechanism	Applicable Aging Effect
Aluminum (bus, solid and flexible connectors and ground straps)	Connection surface oxidation	None identified
Silicone caulk	Temperature Radiation	None identified
Steel (bolts, washers, nuts and clamp screws)	Precipitation	None identified
Rigid bus parts	Vibration	None Identified

9.6 Operating Experience — Isolated-Phase Bus

Industry and Oconee operating experience is reviewed below.

9.6.1 Industry Experience

The industry experience review included a search of NRC generic communications. The following documents were identified in this search:

- Bulletin 79-27, Loss of Non-Class 1E Instrumentation and Control Power System Bus During Operation
- Generic Letter 91-11, Resolution of Generic Issues 48, “LCOs for Class 1E Vital Instrument Buses,” and 49, “Interlocks and LCOs for Class 1E Tie Breakers,” Pursuant to 10 CFR 50.54(f)
- IN 86-87, Loss of Offsite Power Upon an Automatic Bus Transfer
- IN 86-100, Loss of Offsite Power to Vital Buses at Salem 2
- IN 88-55, Potential Problems Caused by Single Failure of an Engineered Safety Feature Swing Bus
- IN 89-64, Electrical Bus Bar Failures
- IN 91-57, Operational Experience on Bus Transfers
- IN 92-09, Overloading and Subsequent Lockout of Electrical Buses During Accident Conditions

- IN 92-40, Inadequate Testing of Emergency Bus Undervoltage Logic Circuitry
- IN 93-28, Failure to Consider Loss of DC Bus in Emergency Core Cooling System Evaluation May Lead to Nonconservative Analysis

No unique aging effects were identified in the above documents beyond those identified in this chapter.

9.6.2 Oconee Experience

Oconee operating experience was reviewed to identify applicable aging effects for electrical bus. This review included a survey of documented instances of component aging along with interviews of responsible engineering personnel. No unique aging effects were identified from the review beyond those identified in this chapter.

9.7 AMR Conclusion — Isolated-Phase Bus

Based on the review of industry information, NRC generic communications and Oconee operating experience, no aging effects are applicable for isolated-phase bus subject to an AMR for the extended period of operation. Therefore, no aging management is necessary.

10
NONSEGREGATED-PHASE BUS

This section continues the electrical integrated plant assessment (IPA) by reviewing electrical nonsegregated-phase bus. All remaining electrical IPA work related to nonsegregated-phase bus installed at Oconee is documented in this section. The process outlined in Figure 1-1 is followed in this section for nonsegregated-phase bus.

General Description
Nonsegregated-phase bus is electrical bus constructed with all phase conductors in a common metal enclosure without barriers (only air space) between the phases [Reference 17]. Nonsegregated-phase bus is used in the Oconee 4160V and 6900V power systems to connect various elements in electric power circuits such as switchgear, transformers and disconnect switches. Not all parts of these high voltage systems use bus to connect components. For example, cable is used for the 4160V feeders from the SSF diesel generator and the 4160V feeders from transformer CT5.

Nonsegregated-phase bus structural supports are reviewed in the structures and structural support AMR for license renewal [Reference 30].

10.1 List — Nonsegregated-Phase Bus

No nonsegregated-phase bus is excluded from the AMR in Chapters 3, 4 or 5. Therefore, an encompassing group (as described in Section 1.2) of all nonsegregated -phase bus is included in the AMR.

Plant walkdowns, electrical system one-line drawings and the nonsegregated-phase bus design specifications [Reference 75] were used to identify nonsegregated-phase bus installed at Oconee. The complete list is given in the following table along with their installed locations in the plant.

Table 10-1
Included in the AMR — Nonsegregated-Phase Bus

Description	Installed Locations
All sections of Oconee Unit 1 4160V Nonsegregated-Phase Bus	Turbine Building Unit 1&2 Switchgear Blockhouse Oconee Transformer Yard
All sections of Oconee Unit 2 4160V Nonsegregated-Phase Bus	Turbine Building Unit 1&2 Switchgear Blockhouse Oconee Transformer Yard
All sections of Oconee Unit 3 4160V Nonsegregated-Phase Bus	Turbine Building Unit 3 Switchgear Blockhouse Oconee Transformer Yard
All sections of Oconee Unit 1 6900V Nonsegregated-Phase Bus	Turbine Building Unit 1&2 Switchgear Blockhouse Oconee Transformer Yard
All sections of Oconee Unit 2 6900V Nonsegregated-Phase Bus	Turbine Building Unit 1&2 Switchgear Blockhouse Oconee Transformer Yard
All sections of Oconee Unit 3 6900V Nonsegregated-Phase Bus	Oconee Transformer Yard

10.2 Component Boundaries — Nonsegregated-Phase Bus

Nonsegregated-phase bus connects two or more elements (electrical equipment; e.g., switchgear, transformers) of an electrical circuit. The point where a nonsegregated-phase bus enters an enclosure and the bus connects to the equipment (and all parts within the enclosure) are considered part of the electrical equipment. This boundary is justified since equipment connection enclosures are inspected and maintained as part of the equipment [Reference 76]. Nonsegregated-phase bus structural supports are reviewed in the structures and structural components AMR for license renewal [Reference 30]. Therefore, the evaluation of nonsegregated-phase bus includes only the bus sections and not the bus connections to other electrical equipment.

10.3 Materials — Nonsegregated-Phase Bus

The figures below show a cross-section of a typical nonsegregated-phase bus and a cut-away of a baffle bushing assembly as shown on the manufacturers drawings.

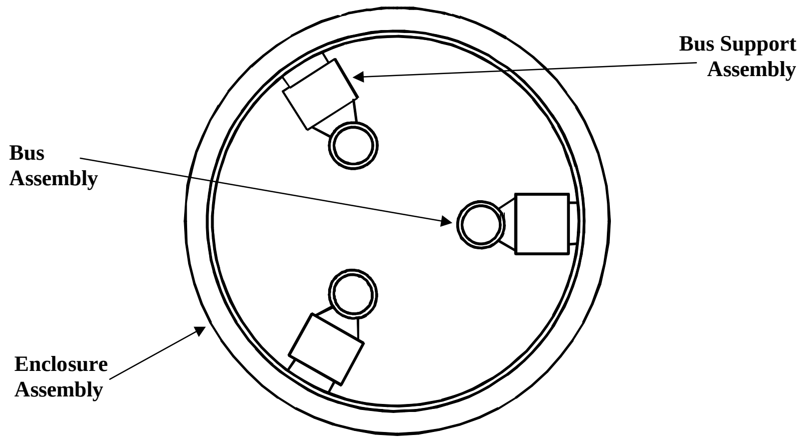

Figure 10-1
Cross-Section of Typical Nonsegregated-Phase Bus: Bus Assembly, Bus Support Assembly, Enclosure Assembly

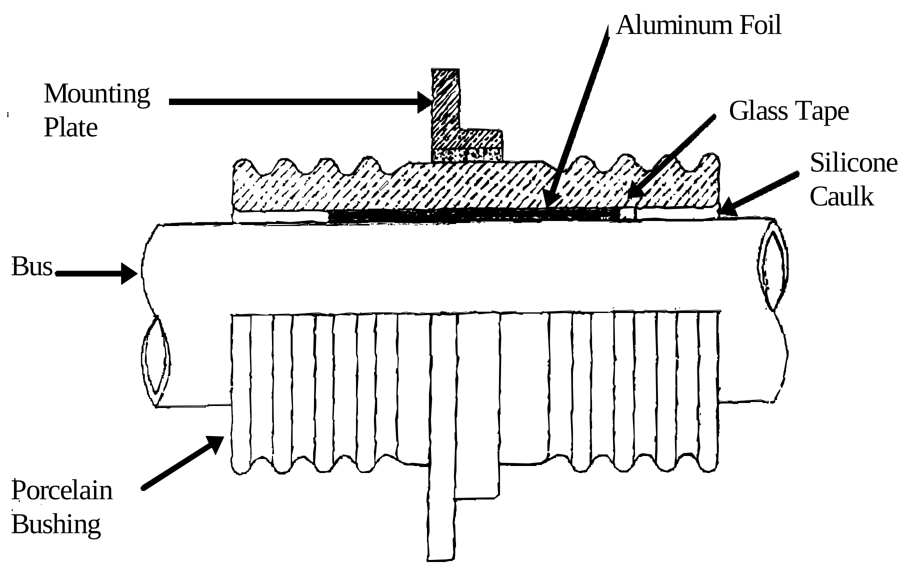

Figure 10-2
Cut-Away Section of Typical Nonsegregated-Phase Bus: Baffle Bushing Assembly

As a convenience to identify the materials that make up nonsegregated-phase bus, the bus is separated into definable parts. These parts are listed below and then described in following sections.

- bus assembly
- bus support assembly
- enclosure assembly
- baffle bushing assembly

Manufacturing parts information is from Oconee manufacturers drawings and interviews with bus inspection personnel [Reference 71].

10.3.1 Bus Assembly

The bus assembly is the electrical conductor for the bus. It is constructed with aluminum pipe, aluminum solid connectors, aluminum or copper flexible connectors and stainless steel or bronze bolts/washers/nuts. The aluminum pipe is used for the straight sections of bus and has a flat pad welded to each end. Solid connectors and flexible connectors are used to connect bus sections together and to other equipment. The bolts/washers/nuts are used to fasten all these parts together. No-Ox grease (Mobilgrease 28) is used on all bolted aluminum electrical connections to prevent the formation of aluminum oxide on connection surfaces. No-Ox grease is a consumable that is replaced during each routine maintenance of the bus and is not reviewed. The bus assembly materials reviewed are:

- aluminum (bus, solid and flexible connectors)
- bronze (bolts/washers/nuts)
- copper (flexible connectors)
- stainless steel (bolts/washers/nuts)

10.3.2 Bus Support Assembly

The bus support assembly supports the bus and insulates it from the enclosure. It is composed of a metal cap (made of various galvanized metals such as malleable iron, ductile iron and drop-forged steel) attached to both ends of a porcelain insulator. The porcelain insulator is smaller but similar to the post insulator shown in Figure 8-2. The cap on one end is contoured to fit the outer shape of the bus and the cap on the other end is contoured to fit the inner wall of the enclosure. The bus support assembly materials reviewed are:

- galvanized metals (insulator caps)
- porcelain (insulators)

10.3.3 Enclosure Assembly

The enclosure assembly is used to enclose all sections of the bus and support all internal bus parts. Some bus sections have fixed covers and some sections have removable covers that are clamped in place. The removable covers allow access to the inside of the bus. A cork/neoprene gasket provides a seal around the removable portion of the enclosure. The gasket is a consumable that is inspected and replaced as needed during each routine maintenance of the bus and is not reviewed. Laminated aluminum ground straps are used to provide continuous ground connections across the removable portions of the enclosure. Grease is used on ground strap electrical connections to prevent the formation of aluminum oxide on connection surfaces. Grease is a consumable that is replaced during each routine maintenance of the bus and is not reviewed. The ground straps are fastened to the enclosure with steel bolts. Each bus support assembly is held in place by a steel bolt inserted through the outside of the bus enclosure. A rubber o-ring provides a seal around the bolt heads. The o-ring is a consumable that is inspected and replaced as needed during each routine maintenance of the bus and is not reviewed. The enclosure assembly materials reviewed are:

- aluminum (covers, clamps, ground straps)
- steel (clamp screws, bolts)

10.3.4 Baffle Bushing Assembly

Baffle bushing assemblies are installed where the bus passes through a switchgear blockhouse wall from the Oconee Transformer Yard. The baffle bushing assemblies provide a thermal barrier that prevents condensation. A baffle bushing assembly is constructed with three porcelain bushings (through which the phase buses pass), aluminum foil, glass tape and silicone caulk (used to fill and seal the area between each phase bus and bushing), a bronze bushing collar (attached to the bushing with grout), an aluminum wall plate (used to mount the bushing collar to the wall) and steel bolts/washers/nuts (to fasten metal parts together and to the wall). Baffle bushing assembly materials reviewed are:

- aluminum (wall plate, foil between bus and bushing)
- bronze (bushing collar)
- glass tape (between bus and bushing)
- grout (between bushing and bushing collar)
- porcelain (bushings)
- silicone caulk (between bus and bushing)
- steel (bolts/washers/nuts)

10.3.5 Results — Materials

The nonsegregated-phase bus materials reviewed, as described above, are listed in the following table.

Table 10-2
Materials Reviewed — Nonsegregated-Phase Bus

Materials Reviewed	Part of Bus Where Material Is Used			
	Bus Assembly	**Bus Support Assembly**	**Enclosure Assembly**	**Baffle Bushing Assembly**
Aluminum	bus, solid and flexible connectors		covers, clamps, ground straps	wall plate, foil between bus and bushing
Bronze	bolts, washers, nuts			bushing collar
Copper	flexible connectors			
Galvanized Metal		insulator caps		
Glass Tape				between bus and bushing
Grout				between bushing and bushing collar
Porcelain		insulators		bushings
Silicone Caulk				between bus and bushing
Stainless Steel	bolts, washers, nuts			
Steel			clamp screws, bolts	bolts, washers, nuts

10.4 Service Conditions — Nonsegregated-Phase Bus

The two aspects of service conditions—environmental conditions and self-heating temperature rise—are discussed below in separate sections.

10.4.1 Environmental Conditions

Nonsegregated-phase bus is installed in the locations identified in Table 10-1. Reviewing the environmental condition data included in Chapter 15 for thermal environments (Table A-2), radiation environments (Table A-3) and moisture environments (Table A-4) gives the information in the following table. This table outlines the nonsegregated-phase bus environmental conditions.

Table 10-3
Environmental Conditions — Nonsegregated-Phase Bus

Stressor	Part of Bus	Bounding Value
Temperature	All	105°F (40.6°C)
Radiation	All	Less than 1.5 x 10^3 rads
Moisture	Parts exposed to outside environment: • Enclosure Assembly - aluminum covers, clamps, ground straps - steel clamp screws, bolts • Baffle Bushing Assembly - aluminum wall plate - steel bolts, washers, nuts	Precipitation

10.4.2 Self-Heating Temperature Rise

Oconee drawings indicate that the nonsegregated-phase bus is rated for a maximum temperature rise of 65°C due to self-heating temperature rise when operating in a 40°C (104°F) ambient. The actual self-heating temperature rise is approximately 35.4°C [Reference 77]. To remain conservative, a bounding 40°C self-heating temperature rise is used.

ANSI/IEEE C37.23 [Reference 78, Table 1] shows the maximum design temperature rise for the two main components of a metal-enclosed bus. This table recognizes that there should be a significant difference between the temperature rise for the conductor and the enclosure so the enclosure would be less hot to the touch. Although no enclosure design temperature rise values were found, it is reasonable that the same temperature rise relationship between the conductor and enclosure exists for the Oconee design. Therefore, a maximum temperature rise of 15°C (25°C less than the conductor temperature rise) is used for the enclosure. The self-heating temperature rise for the different parts of the nonsegregated-phase bus is shown in the following table.

Table 10-4
Self-Heating Temperature Rise — Nonsegregated-Phase Bus

Part of Bus	Self-Heating Temperature Rise	Maximum Self-Heating Temperature Rise Given In ANSI/IEEE C37.23 (used for relationship only)
Bus parts close to or part of the conductor: • Bus Assembly - aluminum bus, solid and flexible connectors - bronze bolts, washers, nuts - copper flexible connectors - stainless steel bolts, washers, nuts • Bus Support Assembly - galvanized metal insulator caps - porcelain insulator • Baffle Bushing Assembly - aluminum foil between bus and bushing - glass tape between bus and bushing - porcelain bushing - silicone caulk between bus and bushing	40°C	65°C
Bus parts not close to or part of the conductor: • Enclosure Assembly - aluminum covers, clamps, ground straps - steel clamp screws, ground strap bolts • Baffle Bushing Assembly - aluminum wall plate - bronze bushing collar - grout between bushing and bushing collar - steel bolts, washers, nuts	15°C	40°C

10.4.3 Results — Service Conditions

Service conditions for nonsegregated-phase bus are obtained by combining the environmental conditions information given in Table 10-3 with the self-heating temperature rise information given in Table 10-4. The results are presented in the following table.

Table 10-5
Service Conditions — Nonsegregated-Phase Bus

Stressor	Part of Bus	Bounding Value
Temperature	Bus parts close to or part of the conductor: • Bus Assembly - aluminum bus, solid and flexible connectors - bronze bolts, washers, nuts - copper flexible connectors - stainless steel bolts, washers, nuts • Bus Support Assembly - galvanized metal insulator caps - porcelain insulator • Baffle Bushing Assembly - aluminum foil between bus and bushing - glass tape between bus and bushing - porcelain bushing - silicone caulk between bus and bushing	177°F (80.6°C)
	Bus parts not close to or part of the conductor: • Enclosure Assembly - aluminum covers, clamps, ground straps - steel clamp screws, ground strap bolts • Baffle Bushing Assembly - aluminum wall plate - bronze bushing collar - grout between bushing and bushing collar - steel bolts, washers, nuts	132°F (55.6°C)
Radiation	All	Less than 1.5×10^3 rads
Moisture	Parts exposed to outside environment: • Enclosure Assembly - aluminum covers, clamps, ground straps - steel clamp screws, bolts • Baffle Bushing Assembly - aluminum wall plate - steel bolts, washers, nuts	Precipitation

10.5 Aging Effects — Nonsegregated-Phase Bus

The potential aging effects for nonsegregated-phase bus are listed in the following table.

Table 10-6
Potential Aging Effects — Nonsegregated-Phase Bus

Material	Stressor Or Mechanism	Potential Aging Effect
Aluminum (bus, solid and flexible connectors and ground straps)	Connection surface oxidation	Change in material properties leading to increased resistance and heating
Silicone caulk	Temperature Radiation	Change in material properties leading to loss of maintained spacing between the bus and bushing
Steel (bolts, washers, nuts and clamp screws)	Precipitation	Change in material properties (corrosion) leading to loss of function for the part
Rigid bus parts	Vibration	Cracking

Except for rigid parts exposed to vibration, the applicability of aging effects for these same materials which are exposed to the same stressors is assessed in Section 9.5, Aging Effects — Isolated-Phase Bus. It is determined in Section 9.5 that the aging effects are not applicable for the extended period of operation. The applicability of vibration aging effects for rigid bus parts is assessed in the following section.

10.5.1 Rigid Bus Parts — Vibration

Nonsegregated-phase bus is connected to static equipment that does not normally vibrate such as switchgear, transformers and disconnect switches. Nonsegregated-phase bus is supported by static structural components such as cement footings and building steel. With no connections to moving or vibrating equipment, vibration is not an applicable stressor for nonsegregated bus and aging effects due to vibration are not applicable.

10.5.2 Results — Aging Effects

The information given in the section above and in Table 9-7, is summarized in the following table.

Table 10-7
Applicable Aging Effects — Nonsegregated-Phase Bus

Material	Stressor Or Mechanism	Applicable Aging Effect
Aluminum (bus, solid and flexible connectors and ground straps)	Connection surface oxidation	None identified
Silicone caulk	Temperature Radiation	None identified
Steel (bolts, washers, nuts and clamp screws)	Precipitation	None identified
Rigid bus parts	Vibration	None identified

10.6 Operating Experience — Nonsegregated-Phase Bus

Industry and Oconee operating experience for nonsegregated-phase bus is the same as that for isolated-phase bus which is reviewed in Section 9.6. As documented in that section, no unique aging effects were identified in the above documents beyond those identified in this chapter.

10.7 AMR Conclusion — Nonsegregated-Phase Bus

Based on the review of industry information, NRC generic communications and Oconee operating experience, no aging effects are applicable for nonsegregated-phase bus subject to an AMR for the extended period of operation. Therefore, no aging management is necessary.

11
SEGREGATED-PHASE BUS

This section continues the electrical integrated plant assessment (IPA) by reviewing electrical segregated-phase bus. All remaining electrical IPA work related to segregated-phase bus installed at Oconee is documented in this section. The process outlined in Figure 1-1 is followed in this section for segregated-phase bus.

General Description
Segregated-phase bus is an electrical bus in which all phase conductors are in a common metal enclosure, but are segregated by metal barriers between phases [Reference 17]. Segregated-phase bus is installed only at Oconee only in portions of the 13.8kV power system at Keowee Hydroelectric Station.

Segregated-phase bus structural supports are reviewed in the structures and structural components AMR for license renewal [Reference 30].

11.1 List — Segregated-Phase Bus

No segregated-phase bus is excluded from the AMR in Chapters 3, 4 or 5. Therefore, an encompassing group (as described in Section 1.2) of all segregated -phase bus is included in the AMR.

Segregated-phase bus is used in two applications for each Keowee unit. One section of segregated-phase bus on each unit connects the generator terminals to the main switchgear. This section is installed in the Keowee Powerhouse on elevation 683'+6" near the ceiling, penetrates through the floor into the bottom of the main switchgear on the main operating floor. The other section of segregated-phase bus connects the main switchgear of each unit to the underground feeder switchgear in the Keowee Breaker Vault. [Footnote 11] These sections of segregated-phase bus are located in the Keowee Powerhouse approximately 15 feet above the floor on the operating level.

Keowee one-line drawings along with a plant walkdown confirmed the location and identification of all segregated-phase bus. The complete list is given in the following table using bus section names and terminal points for identification. The location given is the location of the bus terminal.

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11. **Keowee Breaker Vault:** A part of the Keowee Powerhouse that is separated from the Powerhouse interior by concrete walls and a large, steel, roll-away door. It houses the switchgear that connects Keowee to the underground power path terminating at Transformer CT4 in the Oconee Unit 1 & 2 Blockhouse.

Table 11-1
Included in an AMR — Segregated-Phase Bus

Description	Installed Location
Keowee Unit 1 Generator Bus	Keowee Powerhouse
Keowee Unit 1 Underground Feeder Bus	Keowee Powerhouse Keowee Breaker Vault
Keowee Unit 2 Generator Bus	Keowee Powerhouse
Keowee Unit 2 Underground Feeder Bus	Keowee Powerhouse Keowee Breaker Vault

11.2 Component Boundaries — Segregated-Phase Bus

Segregated-phase bus connects two elements (electrical equipment; e.g., generator, switchgear) of an electrical circuit. The point where a segregated-phase bus enters an enclosure and the bus connects to the equipment (and all parts within the enclosure) are considered part of the electrical equipment. This boundary is justified since equipment connection enclosures are inspected and maintained as part of the equipment. Segregated-phase bus also interfaces with structural steel supports connected to steel structures, which are reviewed, as appropriate, in the structures and structural components AMR specification for license renewal [Reference 30]. Therefore, the evaluation of segregated-phase bus includes only the bus in the bus run and not supports of the bus connections to other electrical equipment.

11.3 Materials — Segregated-Phase Bus

The figure below is a typical cross-section segregated-phase bus showing the bus assembly, bus support assembly and enclosure assembly as shown on manufacturers drawings.

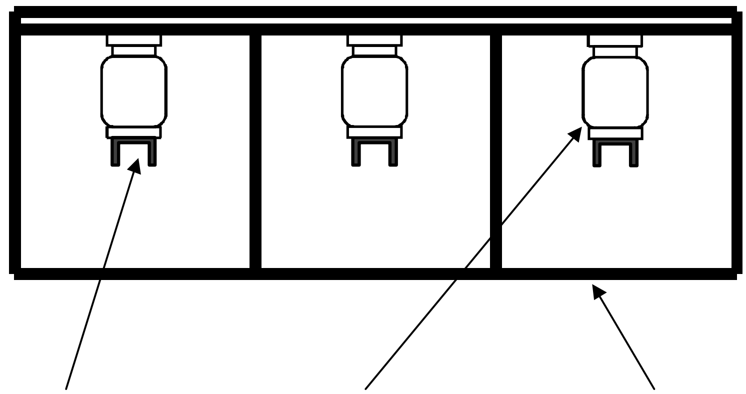

Figure 11-1
Typical Cross-Section — Segregated-Phase Bus: Bus Assembly, Bus Support Assembly, Enclosure Assembly

As a convenience to identify the materials that make up segregated-phase bus, the bus is separated into definable parts. These parts are listed below and then described in following sections.

- bus assembly
- bus support assembly
- enclosure assembly

Parts and materials information is from Keowee manufacturers drawings and from Duke personnel that have inspected the bus [Reference 71].

11.3.1 Bus Assembly

The bus assembly is the electrical conductor for the bus. The main portion of the bus is constructed with channel aluminum, aluminum spacers, aluminum or copper flexible connectors and bronze or stainless steel bolts/washers/nuts. The channel aluminum is used for the straight sections of bus. The spacers are used to maintain spacing of the two halves of the channel aluminum. The flexible connectors are used to connect conductor sections together, conductor sections to other components and the conductor to the baffle bushing assemblies. The bolts/washers/nuts are used to fasten all these parts together. Grease is used on all bolted aluminum electrical connections to prevent the formation of aluminum oxide on connection surfaces. Grease is a consumable that is replaced during each routine maintenance of the bus and is not reviewed. The bus assembly is constructed of:

- aluminum (bus, solid and flexible connectors)
- bronze (bolts/washers/nuts)
- copper (flexible connectors)
- stainless steel (bolts/washers/nuts)

11.3.2 Bus Support Assembly

The bus support assembly supports and insulates the bus conductor from the enclosure. It is composed of a metal cap (made of various galvanized metals such as malleable iron, ductile iron and drop-forged steel) attached to both ends of a porcelain insulator. The porcelain insulator is smaller but similar to the post insulator shown in Figure 1-1). The insulator is supported by an aluminum mounting bar and support foot. Steel bolts/washers/nuts are used to fasten these parts together. The bus support assembly materials reviewed are:

- aluminum (mounting bar, support foot)
- galvanized metal (insulator caps)
- porcelain (insulator)
- steel (bolts/washers/nuts)

11.3.3 Enclosure Assembly

The enclosure assembly is used to enclose all sections of the bus. The enclosures are constructed of aluminum and fastened in place using steel bolts/washers/nuts. The bottom side of many sections of the enclosure is removable and serves as inspection ports. A cork/neoprene gasket provides a seal around the edge of the removable portion of the enclosure. The gasket is a consumable that is inspected and replaced as needed during each routine maintenance of the bus and is not reviewed. Laminated aluminum ground straps are used to provide continuous ground connections across these removable portions of the enclosure. Steel bolts are used to fasten the ground straps in place. Grease is used on ground strap electrical connections to prevent the formation of aluminum oxide on connection surfaces. Grease is a consumable that is replaced during each routine maintenance of the bus and is not reviewed. The enclosure assemblies are constructed of:

- aluminum (covers, ground straps)
- steel (bolts/washers/nuts)

The segregated-phase bus materials reviewed as described above are listed in the following table.

Table 11-2
Materials Reviewed — Segregated-Phase Bus

Materials Reviewed	Part of Bus Where Material Is Used		
	Bus Assembly	Bus Support Assembly	Enclosure Assembly
Aluminum	bus, solid and flexible connectors	mounting bar, support foot	covers, ground straps
Bronze	bolts, washers, nuts		
Copper	flexible connectors		
Galvanized Metals		insulator caps	
Porcelain		insulator	
Stainless Steel	bolts, washers, nuts		
Steel		bolts, washers, nuts	bolts, washers, nuts

11.4 Service Conditions — Segregated-Phase Bus

The two aspects of service conditions—environmental conditions and self-heating temperature rise—are discussed below in separate sections.

11.4.1 Environmental Conditions — Segregated-Phase Bus

Segregated-phase bus is installed in the locations identified in Table 11-1. Reviewing the environmental condition data included in Appendix A for thermal environments (Table A-2), radiation environments (Table A-3) and moisture environments (Table A-4) gives the segregated-phase bus environmental conditions.

Table 11-3
Environmental Conditions — Segregated-Phase Bus

Stressor	Part of Bus	Bounding Value
Temperature	All parts of bus	105°F (40.6°C)
Radiation	All parts of bus	Negligible
Moisture	All parts of bus	N/A

11.4.2 Self-Heating Temperature Rise — Segregated-Phase Bus

Self-heating temperature rise of a bus is discussed in detail in Section 10.4.2. The conclusions of that discussion is that the parts of the bus close to or part of the conductor will be exposed to a maximum self-heating temperature rise of 40°C above ambient and the other parts of the bus will have a self-heating temperature rise of 15°C above ambient. These are highly conservative values for long-term aging given that each Keowee generating unit has operated (and the segregated-phase bus has carried current) less than 7% of the time [Reference 72]. The self-heating temperature rise for the different parts of the segregated-phase bus is shown in the following table.

Table 11-4
Self-Heating Temperature Rise — Segregated-Phase Bus

Part of Bus	Self-Heating Temperature Rise
Bus parts close to or part of the conductor: • Bus Assembly - aluminum bus, solid and flexible connectors - bronze bolts, washers, nuts - copper flexible connectors - stainless steel bolts, washers, nuts • Bus Support Assembly - galvanized metal insulator caps - porcelain insulator	40°C
Bus parts not close to or part of the conductor: • Bus Support Assembly - aluminum mounting bar, support foot - steel bolts, washers, nuts • Enclosure Assembly - aluminum covers, ground straps - steel bolts, washers, nuts	15°C

11.4.3 Results — Service Conditions

Service conditions for segregated-phase bus are obtained by combining the environmental conditions information given in Table 11-2 with the self-heating temperature rise information given in Table 11-3. The results are presented in the following table.

Table 11-5
Service Conditions — Segregated-Phase Bus

Stressor	Part of Bus	Bounding Value
Temperature	Bus parts close to or part of the conductor: • Bus Assembly - aluminum bus, solid and flexible connectors - bronze bolts, washers, nuts - copper flexible connectors - stainless steel bolts, washers, nuts • Bus Support Assembly - galvanized metal insulator caps - porcelain insulator	177°F (80.6°C)
	Bus parts not close to or part of the conductor: • Bus Support Assembly - aluminum mounting bar, support foot - steel bolts, washers, nuts • Enclosure Assembly - aluminum covers, ground straps - steel bolts, washers, nuts	132°F (55.6°C)
Radiation	All	Negligible
Moisture	All	N/A

11.5 Aging Effects — Segregated-Phase Bus

The potential aging effects for segregated-phase bus are listed in the following table.

Table 11-6
Potential Aging Effects — Segregated-Phase Bus

Material	Stressor or Mechanism	Potential Aging Effect
Aluminum (bus, solid and flexible connectors and ground straps)	Connection surface oxidation	Change in material properties leading to increased resistance and heating
Rigid bus parts	Vibration	Cracking

The applicability of this aging effect for aluminum in the same service conditions is assessed in Section 9.5, Aging Effects — Isolated-Phase Bus. The review of vibration for isolated-phase bus is also applicable to segregated-phase bus since they are both connected to generators through flexible connections. It is determined in Section 9.5 that there are no applicable aging effects for the aluminum bus, solid and flexible connectors, ground straps, or other rigid bus parts when exposed to their service conditions for the extended period of operation. With the same materials, service conditions and stressors as found for isolated-phase bus, the aging effects are also the same. Therefore, the applicable information given in Table 9-7, is provided in the following table.

Table 11-7
Applicable Aging Effects — Segregated-Phase Bus

Material	Stressor or Mechanism	Applicable Aging Effect
Aluminum (bus, solid and flexible connectors and ground straps)	Connection surface oxidation	None identified
Rigid bus parts	Vibration	Non identified

11.6 Operating Experience — Segregated-Phase Bus

Industry and Oconee operating experience for segregated-phase bus is the same as that for isolated-phase bus which is reviewed in Section 9.6. As documented in that section, no unique aging effects were identified in the above documents beyond those identified in this chapter.

11.7 AMR Conclusion — Segregated-Phase Bus

Based on the review of industry information, NRC generic communications and Oconee operating experience, no aging effects are applicable for segregated-phase bus subject to an AMR for the extended period of operation. Therefore, no aging management is necessary.

12 SWITCHYARD BUS

This section continues the electrical integrated plant assessment (IPA) by reviewing electrical switchyard bus. All remaining electrical IPA work related to switchyard bus installed at Oconee is documented in this section. The process outlined in Figure 1-1 is followed in this section for switchyard bus.

General Description
Switchyard bus is uninsulated, unenclosed, rigid electrical conductor used in switchyards and switching stations to provide an electrically common connection point for disconnect switches and flexible conductors. Switchyard bus interfaces with transmission conductors, which are reviewed in Chapter 13 and insulators, which are reviewed in Chapter 8 of this specification.

12.1 List—Switchyard Bus

Chapter 3 concluded that switchyard bus associated with the 525kV Switchyard and the Oconee 44kV Retail substation do not meet the criteria of §54.4(a). Therefore, an encompassing group (as described in Section 1.2) of all switchyard bus, except switchyard bus (1) associated with the 525kV Switchyard or (2) associated with the Oconee 44kV Retail substation, is included in the AMR.

Switchyard bus is installed in the 230kV Switchyard, the 525kV Switchyard, the 100kV Switching Station, the Oconee Transformer Yard on the Unit 3 main step-up (MSU) transformer bus line to the 525kV Switchyard and in the Oconee 44kV Retail substation. The 230kV Switchyard, 525kV Switchyard and the Oconee Transformer Yard are located East of the Turbine Buildings. The 100kV Switching Station and Oconee 44kV Retail substation are located on the West side of the Reactor Buildings. These locations were identified during plant walkdowns. Per Section 3.1, electrical components associated with the 525kV Switchyard (including the bus line to Unit 3) or Oconee 44kV Retail substation are not within scope and, therefore, are not included in the AMR. The list of switchyard bus included in the AMR is provided in the following table.

Table 12-1
Included In The AMR — Switchyard Bus

Description
All switchyard bus in the 230kV Switchyard
All switchyard bus in the 100kV Switching Station

12.2 Component Boundaries — Switchyard Bus

Switchyard bus is used to provide an electrically common connection point for disconnect (gang) switches and flexible conductors. Switchyard bus is supported by insulators. The review of switchyard bus includes the switchyard bus and the hardware used to secure the bus to an insulator. Since the connections to disconnect switches are maintained as part of the switch, switchyard bus connections to disconnect switches are considered a part of the disconnect switch. Flexible conductors and their connections are reviewed in Chapter 13, Transmission Conductors.

12.3 Materials — Switchyard Bus

The 230kV Switchyard bus includes the large bus that runs the full length of the switchyard, smaller bus that connects the large bus to disconnect switches and the smaller bus that runs between disconnect switches elsewhere in the switchyard. Both the larger and smaller bus is constructed of aluminum pipe. The insulator fastening hardware is made of specifically designed cast aluminum. The materials data for the bus and insulator fastening hardware is from manufacturers drawings. Switchyard bus includes the material listed in the following table.

Table 12-2
Materials — Switchyard Bus

Material	Part of Bus Where Material Is Used	
	Bus	Insulator Fastening Hardware
Aluminum	•	•

12.4 Service Conditions — Switchyard Bus

The two aspects of service conditions—environmental conditions and self-heating temperature rise—are discussed below in separate sections.

12.4.1 Environmental Conditions — Switchyard Bus

Switchyard bus is installed in areas exposed to outside ambient conditions. Reviewing the environmental condition data included in Appendix A for thermal environments (Table A-2), radiation environments (Table A-3) and moisture environments (Table A-4) gives the information in the following table. This table outlines the switchyard bus environmental conditions.

Table 12-3
Environmental Conditions — Switchyard Bus

Stressor	Part of Bus	Bounding Value
Temperature	All	105°F (40.6°C)
Radiation	All	Negligible
Moisture	All	Precipitation

12.4.2 Self-Heating Temperature Rise — Switchyard Bus

The 230kV Switchyard bus and connections current ratings are based on a 30°C temperature rise over a 40°C ambient temperature (as indicated on manufacturers drawings). Rather than determining the actual self-heating temperature rise, a bounding approach of using the full 30°C design value is used for the self-heating temperature rise for all switchyard bus included in the AMR.

Table 12-4
Self-Heating Temperature Rise — Switchyard Bus

Part of Bus	Self-Heating Temperature Rise
All parts of bus	30°C

12.4.3 Results — Service Conditions

Service conditions for switchyard bus are obtained by combining the environmental conditions information given in Table 12-3 with the self-heating temperature rise information given in Table 12-4. The results are presented in the following table.

Table 12-5
Service Conditions — Switchyard Bus

Stressor	Part of Bus	Bounding Value
Temperature	All parts of the bus	159°F (70.6°C)
Radiation	All parts of the bus	Negligible
Humidity	All parts of the bus	Precipitation

12.5 Aging Effects — Switchyard Bus

Aluminum (in non-conductor applications; i.e., insulator fastening hardware) has no applicable aging effects under its service conditions. Aluminum in conductor applications may be susceptible to change in material properties. This potential aging effect is listed in the following table. In addition, vibration was introduced as a potential stressor by the NRC staff in their requests for additional information (RAIs) [Reference 11, Attachment 3] and is addressed.

Table 12-6
Potential Aging Effects — Switchyard Bus

Material	Stressor Or Mechanism	Potential Aging Effect
Aluminum (bus)	Connection surface oxidation	Change in material properties leading to increased resistance and heating
Switchyard bus	Vibration	Cracking

The applicability of these aging effects is assessed in the following sections.

12.5.1 Aluminum Bus — Connection Surface Oxidation

All bus connections within the component boundaries are welded connections. For the ambient environmental conditions at Oconee, no aging effects have been identified that could cause a loss of intended function for the extended period of operation. Therefore, there are no applicable aging effects for the aluminum bus.

12.5.2 Switchyard Bus — Vibration

Switchyard buses are connected to flexible conductors that do not normally vibrate and are supported by insulators and ultimately by static, structural components such as cement footings and structural steel. With no connections to moving or vibrating equipment, vibration is not an applicable stressor for switchyard bus and aging effects due to vibration are not applicable.

12.5.3 Results — Aging Effects

The information given in the sections above is summarized in the following table.

Table 12-7
Applicable Aging Effects — Isolated-Phase Bus

Material	Stressor or Mechanism	Applicable Aging Effect
Aluminum (bus)	Connection surface oxidation	None identified
Switchyard bus	Vibration	None identified

12.6 Operating Experience — Switchyard Bus

Operating experience is reviewed in the following sections.

12.6.1 Industry Experience

In order to identify aging effects and to assure no additional aging effects exist beyond those discussed herein, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee and NRC NUREGs. No documents involving switchyard bus were identified.

12.6.2 Oconee Experience

Oconee operating experience was reviewed to identify applicable aging effects for switchyard bus. This review included a survey of documented instances of component aging along with interviews of responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this chapter.

12.7 AMR Conclusion — Switchyard Bus

Based on the review of industry information, NRC generic communications and Oconee operating experience, no aging effects are applicable for switchyard bus subject to an AMR for the extended period of operation. Therefore, no aging management is necessary.

13 TRANSMISSION CONDUCTORS

This chapter continues the electrical integrated plant assessment (IPA) by reviewing transmission conductors. All remaining IPA work related to transmission conductors is documented in this chapter. The process outlined in Figure 1-1 is followed in this chapter for line traps.

General Description
Transmission conductors have the intended function to electrically connect two sections of an electrical circuit such as transformers, power circuit breakers and disconnect switches. Transmission conductors are uninsulated, stranded electrical cables and are used outside buildings in high voltage applications. Transmission conductors reviewed in this chapter include shield wires. Transmission conductors do not include rigid conductors used in similar areas. Rigid conductors are addressed as switchyard bus in Chapter 12 of this specification.

13.1 List — Transmission Conductors

Chapter 3 concluded that transmission conductors associated with the 525kV Switchyard, the Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines and the Oconee 44kV Retail substation do not meet the criteria of §54.4(a). Therefore, an encompassing group (as described in Section 1.2) of transmission lines, except those (1) associated with the 525kV Switchyard, (2) associated with the Jocassee, Calhoun, Oconee or Dacus 230kV transmission lines or (3) associated with the Oconee 44kV Retail substation, is included in the AMR.

Transmission conductors are used outside in high voltage applications to connect electrical components. Plant walkdowns in the areas identified in Table 13-1 were used to identify types of transmission conductors in these areas. The types of transmission conductors identified are listed below.

- **Transmission Conductors:** Large uninsulated electrical cables used as the power cables in the electrical circuits.
- **Shield Wires:** Smaller uninsulated electrical cables strung above transmission lines (one shield wire per three-phase circuit).

Shield wires are a different type of transmission conductor but are still considered transmission conductors. Shield wires are implicitly included in all the following discussions regarding transmission conductor.

Transmission conductors typical of those included in the AMR are shown on switchyard layout drawings.

Insulators always support transmission conductors so the locations identified for insulators (Table 8-1) were reviewed and found applicable to transmission conductors. These locations are provided in the following table. Transmission conductors included in the AMR are listed in the following table.

Table 13-1
Included in the AMR — Transmission Conductors

Description
Transmission conductors in the 230kV Switchyard
Transmission conductors in the Keowee 230kV Transformer Yard
230kV transmission conductors in the Oconee Transformer Yard
Transmission conductors in the Keowee 230kV Transmission Line
Transmission conductors in the 100kV Fant Black Line
Transmission conductors in the 100kV Switching Station

13.2 Component Boundaries — Transmission Conductors

Transmission conductors are always supported by a structure such as a transmission tower or strain structure. The transmission conductors must be insulated from these support structures so there is always a high voltage insulator between the conductor and the support. The transmission conductors are secured to the insulators with specifically designed metal hardware. Transmission conductors are terminated at major pieces of equipment (e.g., transformers, PCBs, disconnect switches) or they can be connected to a switchyard bus or another transmission conductor.

Structural supports are reviewed in the structures and structural components AMR specification for license renewal [Reference 30]. Insulators are reviewed in Chapter 8. Switchyard bus is reviewed in Chapter 12. Terminations at major pieces of equipment are part of that equipment and are not included in the transmission conductor review. Therefore, the review of transmission conductors includes the transmission conductors, transmission conductor connections to switchyard bus and other transmission conductors, and the hardware used to secure transmission conductors to insulators.

13.3 Materials — Transmission Conductors

All station transmission and shield wire conductors are category ACSR (aluminum conductor steel reinforced) and are constructed of the same materials:

- Aluminum
- Steel

13.4 Service Conditions — Transmission Conductors

The two aspects of service conditions—environmental conditions and self-heating temperature rise—are discussed below in separate sections.

13.4.1 Environmental Conditions

Transmission conductors are installed in areas exposed to outside ambient conditions. Reviewing the environmental condition data included in Appendix A for thermal environments (Table A-2), radiation environments (Table A-3) and moisture environments (Table A-4) gives the information in the following table. This table outlines the insulator environmental conditions.

Table 13-2
Environmental Conditions — Transmission Conductors

Stressor	Bounding Value
Temperature	105°F (40.6°C)
Radiation	Negligible
Moisture	Precipitation

13.4.2 Self-Heating Temperature Rise

Transmission conductors used in the Oconee Transformer Yard associated with Transformers CT1, CT2 and CT3, the 230kV Keowee Transmission Line and the Keowee Transformer Yard associated with Keowee Transformer 1 are infrequently loaded. The Keowee Transmission Line and Transformer Yard conductors are loaded significantly only when Keowee is generating power to the 230kV Switchyard which is less than 12% of the time [Reference 72]. Self-heating temperature rise is not significant for transmission conductors loaded less than 12% of the time, even if the they are fully loaded. Likewise, the transmission conductors used for Transformers CT1, CT2 and CT3 bus lines are normally used only during start-up and during outages—a low percentage of the time. Self-heating temperature rise for these conductors is not significant. At other times, the Keowee transmission line and Keowee transformer yard conductors feed the internal power loads of one Keowee unit. The internal power loads of one unit are normally less than 1MW. Since the transmission conductors are rated to normally carry more than 200MVA from the Keowee generators, the self-heating temperature rise resulting from 1MW is not significant.

Shield wires normally carry minimal current. Self-heating temperature rise for these conductors is not significant.

There are several conductor sizes used in the 230kV Switchyard and the maximum normal loading for any of these conductors is 68% of its conductor current rating [Reference 79]. Self-heating temperature rise for the transmission conductors included in the AMR is not specifically calculated. Instead, to be conservative, the full design self-heating temperature rise used for the switchyard bus in Section 12.4.2 is also used for all transmission conductors. Applying this 30°C self-heating temperature rise to all transmission conductors included in the AMR is representative or conservative with respect to the actual heat rise to which the conductors are exposed.

Table 13-3
Self-Heating Temperature Rise — Transmission Conductors

Application	Self-Heating Temperature Rise
All transmission conductors included in the AMR	30°C

13.4.3 Results — Service Conditions

Service conditions for transmission conductors are obtained by combining the environmental conditions information given in Table 13-2 with the self-heating temperature rise information given in Table 13-3. The results are presented in the following table.

Table 13-4
Service Conditions — Transmission Conductors

Stressor	Application	Bounding Value
Temperature	All transmission conductors included in the AMR	159.1°F (70.6°C)
Radiation	All	Negligible
Moisture	All	Precipitation

13.5 Aging Effects — Transmission Conductors

The only aging effect for transmission line conductors is loss of conductor strength. Also addressed is vibration, which was introduced as a potential stressor by the NRC staff in their requests for additional information (RAIs) [Reference 11, Attachment 3]. These aging effects are described and assessed below.

13.5.1 Loss of Conductor Strength

The most prevalent mechanism contributing to loss of conductor strength of an ACSR transmission conductor is corrosion, which includes corrosion of the steel core and aluminum strand pitting. For ACSR conductors, degradation begins as a loss of zinc from the galvanized steel core wires. Corrosion rates depend largely on air quality, which includes suspended particles chemistry, SO_2 concentration in air, precipitation, fog chemistry and meteorological conditions [Reference 80, pages 581, 584]. Tests performed by Ontario Hydroelectric showed a

30% loss of composite conductor strength of an 80-year-old ACSR conductor due to corrosion [Reference 69, Appendix B, Item 13].

There is set percentage of composite conductor strength established at which a transmission conductor is replaced. As illustrated below, there is ample strength margin to maintain the transmission conductor intended function through the extended period of operation.

The National Electrical Safety Code (NESC) requires that tension on installed conductors be a maximum of 60% of the ultimate conductor strength. The NESC also sets the maximum tension a conductor must be designed to withstand under heavy load requirements, which includes consideration of ice, wind and temperature. These requirements are reviewed concerning the specific conductors included in the aging management review. The conductors with the smallest ultimate strength margin are 4/0 ACSR (aluminum conductor steel reinforced) will be used as an illustration.

The ultimate strength and the NESC heavy load tension requirements of 4/0 ACSR are 8350 lbs. and 2761 lbs. respectively. The margin between the NESC Heavy Load and the ultimate strength is 5589 lb.; i.e., there is a 67% of ultimate strength margin. The Ontario Hydroelectric study showed a 30% loss of composite conductor strength in an 80-year-old conductor. In the case of the 4/0 ACSR transmission conductors, a 30% loss of ultimate strength would mean that there would still be a 37% ultimate strength margin between what is required by the NESC and the actual conductor strength.

The 4/0 ACSR conductors have the lowest initial design margin of any transmission conductors included in the aging management review. This illustrates with reasonable assurance the transmission conductors will have ample strength through the period of extended operation.

Corrosion of ACSR conductors is a very slow acting aging effect that is even slower for rural areas, such as Oconee, with generally less suspended particles and SO_2 concentrations in the air than urban areas. Duke has been installing and maintaining transmission conductors on its transmission system for more than 50 years and has not yet had to replace any conductors due to aging problems. This supports the conclusion that there are no applicable aging effects that could affect the intended function of the transmission conductors for the period of extended operation.

13.5.2 Vibration

Transmission conductor vibration would be caused by wind loading. Wind loading that can cause a transmission line and insulators to vibrate is considered in the design and installation. Loss of material (wear) and fatigue that could be caused by transmission conductor vibration or sway are found not to be applicable aging effects in that they would not cause a loss of intended function if left unmanaged for the extended period of operation.

13.6 Operating Experience — Transmission Conductors

Operating experience is reviewed in the following sections.

13.6.1 Industry Experience

In order to identify applicable aging effects and to assure no additional aging effects exist beyond those discussed herein, a survey of industry experience was performed. This survey included NRC generic communications, licensee event reports from nuclear power plants other than Oconee and NRC NUREGs. No documents involving transmission conductors were identified.

13.6.2 Oconee Experience

Oconee operating experience was reviewed to identify applicable aging effects for transmission conductors. This review included a survey of documented instances of component aging along with interviews of responsible engineering personnel. No unique aging effects were identified from this review beyond those identified in this chapter.

13.7 AMR Conclusion — Transmission Conductors

Based on the review of industry information, NRC generic communications and Oconee operating experience, no aging effects are applicable for transmission conductors subject to an AMR for the extended period of operation. Therefore, no aging management is necessary.

14
SUMMARY AND CONCLUSIONS

The electrical component IPA process begins with all plant electrical components. Plant electrical components are grouped into commodity groups. A limited set of electrical component commodity groups were not scoped-out or screened-out. The aging management review for these electrical component commodity groups identified no applicable aging effects. With no applicable aging effects, no aging management is required.

Table 14-1 provides the results of the application of the §54.4(a), §54.21(a)(1)(i) and §54.21(a)(1)(ii) scoping and screening criteria to electrical component commodity groups at Oconee along with the results of the aging management review. The table columns are described below:

- **Column 1** lists the complete set of plant electrical component commodity groups installed at Oconee.
- **Column 2** provides the results of the application of the criteria of §54.4(a) to specific groups of electrical components. If the §54.4(a) scoping criteria were not applied to an electrical component commodity group, “Criteria not applied” appears in the block.
- **Column 3** provides the results of the application of the §54.21(a)(1)(i) screening criteria to each electrical component commodity group. “Yes” indicates that the electrical component commodity group meets the §54.21(a)(1)(i) screening criteria and “No” indicates that the electrical component commodity group does not meet the §54.21(a)(1)(i) screening criteria.
- **Column 4** provides the results of the application of the criteria of §54.21(a)(1)(ii) to specific groups of electrical components. If the §54.21(a)(1)(ii) screening criteria were not applied to an electrical component commodity group, “Criteria not applied” appears in the block.
- **Column 5** indicates the electrical components that were not scoped-out or screened-out and are included in the aging management review. If all components within a commodity group are scoped-out or screened-out, the commodity group is not subject to an AMR, “N/A” (not applicable) appears in the block and the block is darkened.
- **Column 6** provides the results of the aging management review.

Table 14-1
Summary Results of the Oconee Electrical Component IPA

1	2	3	4	5	6
Electrical Component Commodity Groups *(see Chapter 2)*	Application of §54.4(a) Criteria *(see Chapter 3)*	Application of §54.21(a)(1)(i) Criteria *(see Chapter 4)*	Application of §54.21(a)(1)(ii) Criteria *(see Chapter 5)*	Electrical Components Included in the AMR	AMR Results
Alarm Units	Criteria not applied	No	Criteria not applied	N/A	N/A
Analyzers	Criteria not applied	No	Criteria not applied	N/A	N/A
Annunciators	Criteria not applied	No	Criteria not applied	N/A	N/A
Batteries	Criteria not applied	No	Criteria not applied	N/A	N/A
Chargers	Criteria not applied	No	Criteria not applied	N/A	N/A
Circuit Breakers	Criteria not applied	No	Criteria not applied	N/A	N/A
Converters	Criteria not applied	No	Criteria not applied	N/A	N/A
Communication Equipment	Criteria not applied	No	Criteria not applied	N/A	N/A
Electrical Controls and Panel Internal Component Assemblies	Criteria not applied	No	Criteria not applied	N/A	N/A
Electrical Penetration Assemblies	Criteria not applied	Yes	Electrical penetration assemblies do not meet the criteria of §54.21(a)(1)(ii).	N/A	N/A
Elements	Criteria not applied	No	Criteria not applied	N/A	N/A
Fuses	Criteria not applied	No.	Criteria not applied	N/A	N/A
Generators	Criteria not applied	No	Criteria not applied	N/A	N/A
Heat Tracing	Criteria not applied	No.	Criteria not applied	N/A	N/A
Heaters	Criteria not applied	No.	Criteria not applied	N/A	N/A
Indicators	Criteria not applied	No	Criteria not applied	N/A	N/A
Insulated Cables and Connections	Insulated cables and connections associated with the (a) 525kV Switchyard, (b) Radwaste Facility and (c) Oconee Retail substation do not meet the criteria of §54.4(a).	Yes	Insulated cables and connections included in the EQ program and insulated cables and connections used for fire detectors do not meet the criteria of §54.21(a)(1)(i).	An encompassing group of all insulated cables and connections except those (1) associated with the 525kV Switchyard, Radwaste Facility, or Oconee Retail substation, (2) included in the EQ program or (3) used for fire detectors is included in the AMR.	Aging management program is included to cover applicable aging effects associated with heat, radiation and moisture. ***(Chapter 7)***

1	2	3	4	5	6
Electrical Component Commodity Groups *(see Chapter 2)*	Application of §54.4(a) Criteria *(see Chapter 3)*	Application of §54.21(a)(1)(i) Criteria *(see Chapter 4)*	Application of §54.21(a)(1)(ii) Criteria *(see Chapter 5)*	Electrical Components Included in the AMR	AMR Results
Insulators	Insulators associated with the (a) 525kV Switchyard, (b) Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines and (c) Oconee Retail substation do not meet the criteria of §54.4(a).	Yes	Criteria not applied	An encompassing group of all insulators except those associated with the (1) 525kV Switchyard, (2) Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines or (3) Oconee Retail substation is included in the AMR.	No applicable aging effects are identified. ***(Chapter 8)***
Inverters	Criteria not applied	No	Criteria not applied	N/A	N/A
Isolated-Phase Bus	Criteria not applied	Yes	Criteria not applied	An encompassing group of all isolated-phase bus is included in the AMR.	No applicable aging effects are identified. ***(Chapter 9)***
Isolators	Criteria not applied	No	Criteria not applied	N/A	N/A
Light Bulbs	Criteria not applied	No	Criteria not applied	N/A	N/A
Load Centers	Criteria not applied	No	Criteria not applied	N/A	N/A
Loop Controllers	Criteria not applied	No	Criteria not applied	N/A	N/A
Meters	Criteria not applied	No	Criteria not applied	N/A	N/A
Motor Control Centers	Criteria not applied	No	Criteria not applied	N/A	N/A
Motors	Criteria not applied	No	Criteria not applied	N/A	N/A
Nonsegregated-Phase Bus	Criteria not applied	Yes	Criteria not applied	An encompassing group of all nonsegregated-phase bus is included in the AMR.	No applicable aging effects are identified. ***(Chapter 10)***
Power Distribution Panels	Criteria not applied	No	Criteria not applied	N/A	N/A
Power Supplies	Criteria not applied	No	Criteria not applied	N/A	N/A
Radiation Monitors	Criteria not applied	No	Criteria not applied	N/A	N/A
Recorders	Criteria not applied	No	Criteria not applied	N/A	N/A
Regulators	Criteria not applied	No	Criteria not applied	N/A	N/A
Relays	Criteria not applied	No	Criteria not applied	N/A	N/A
RTDs	Criteria not applied	No.	Criteria not applied	N/A	N/A
Segregated-Phase Bus	Criteria not applied	Yes	Criteria not applied	An encompassing group of all segregated-phase bus is included in the AMR.	No applicable aging effects are identified. ***(Chapter 11)***
Sensors	Criteria not applied	No	Criteria not applied	N/A	N/A
Signal Conditioners	Criteria not applied	No	Criteria not applied	N/A	N/A
Solenoid Operators	Criteria not applied	No	Criteria not applied	N/A	N/A

1	2	3	4	5	6
Electrical Component Commodity Groups *(see Chapter 2)*	Application of §54.4(a) Criteria *(see Chapter 3)*	Application of §54.21(a)(1)(i) Criteria *(see Chapter 4)*	Application of §54.21(a)(1)(ii) Criteria *(see Chapter 5)*	Electrical Components Included in the AMR	AMR Results
Solid-State Devices	Criteria not applied	No	Criteria not applied	N/A	N/A
Surge Arresters	Criteria not applied	No	Criteria not applied	N/A	N/A
Switches	Criteria not applied	No	Criteria not applied	N/A	N/A
Switchgear	Criteria not applied	No	Criteria not applied	N/A	N/A
Switchyard Bus	Switchyard bus associated with the (a) 525kV Switchyard and (b) Oconee Retail substation do not meet the criteria of §54.4(a).	Yes	Criteria not applied	An encompassing group of all switchyard bus except bus associated with the (1) 525kV Switchyard or (2) Oconee Retail substation is included in the AMR.	No applicable aging effects are identified. ***(Chapter 12)***
Thermocouples	Criteria not applied	No	Criteria not applied	N/A	N/A
Transducers	Criteria not applied	No	Criteria not applied	N/A	N/A
Transformers	Criteria not applied	No	Criteria not applied	N/A	N/A
Transmission Conductors	Transmission conductors associated with the (a) 525kV Switchyard, (b) Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines and (c) Oconee Retail substation do not meet the criteria of §54.4(a).	Yes	Criteria not applied	An encompassing group of all transmission conductors except those associated with the (1) 525kV Switchyard, (2) Jocassee, Calhoun, Oconee and Dacus 230kV transmission lines, or (3) the Oconee Retail substation is included in the AMR.	No applicable aging effects are identified. ***(Chapter 13)***
Transmitters	Criteria not applied	No	Criteria not applied	N/A	N/A
Uninsulated Ground Conductors	Uninsulated ground conductors do not meet the criteria of §54.4(a).	Yes	Criteria not applied	N/A	N/A

A
ENVIRONMENTAL CONDITIONS

A summary by structure and area of all environmental conditions is presented so that the components installed in each area can be analyzed for aging resulting from location-specific, worst-case design environments. The environmental conditions identified in this section are thermal, radiation and moisture. They are discussed in separate sections. First, the structures and areas included in the electrical component AMR are identified in the following section.

A.1 Structures & Areas Included in the Electrical Component AMR

Structures and areas are identified so that relevant environmental data can be obtained. The applicable environments of these identified structures and areas are included in the aging assessment of electrical components to determine the applicability of the identified potential aging effects. Structures and areas are not scoped in this specification; only electrical components are scoped.

All plant areas are included in the aging management review (AMR). In order to put some order to the list, the more important Class 1 and 2 structures are identified separately and all remaining structures and areas are identified as a separate group.

The Class 1 and 2 structures that are specifically identified (i.e., Auxiliary Buildings, Earthen Embankments, Essential Siphon Vacuum Building, Intake Structure, Keowee Structures, Reactor Buildings, Standby Shutdown Facility, Turbine Buildings and Yard Structures) are copied from the specification "Oconee Structures and Structural Component Aging Management Review for License Renewal" [Reference 30, Chapter 4]. These Class 1 and 2 structures are listed first in Table A-1. All remaining structures and areas containing electrical components are included via the last row of Table A-1 under the name "All remaining plant structures and areas." This last row entry represents all Class 3 structures along with direct buried components (i.e., insulated cables and uninsulated ground conductors) which are the only electrical components not supported by a structure.

The structures and areas included in the electrical component AMR are listed in the following table along with a description.

Table A-1
Structures and Areas Included in the Electrical Component Aging Management Review

Structure or Area	Description
Auxiliary Buildings	Includes Auxiliary Buildings, Hot Machine Shop, Spent Fuel Pools for Units 1&2 (shared) and Unit 3 and penetration rooms
Earthen Embankments	Includes Keowee River Dam, Little River Dam and Dikes and Intake Canal Dike
Essential Siphon Vacuum Building	
Intake Structure	CCW pump intake structure
Keowee Structures	Includes Breaker Vault, Intake Structure, Penstock, Power House, Service Bay Structure and Spillway
Reactor Buildings	Internal Structures and the Unit Vents
Standby Shutdown Facility	
Turbine Buildings	Includes Turbine Buildings, Switchgear Enclosures [i.e., Blockhouses] for Units 1&2 (shared) and Unit 3
Yard Structures	Includes 230kV Relay House, 230kV Switchyard, Keowee Transformer Yard [gravel area on the South side of the Keowee Power House] Structures, Trenches, 230kV Towers from Keowee to Oconee, Elevated Water Storage Tank, Transformer Pads for Transformers CT1, CT2, CT3 and Keowee transformer 1
All remaining plant structures and areas	Includes all remaining plant structures and areas not identified earlier in this table. The structures included here are all Class 3 structures. Specifically, this includes the following: • Appendix R Warehouse [Appendix R cable only] • direct buried (cables and ground conductors) • 100kV Switching Station and Transmission Line structures • all other Class 3 structures

A.2 Thermal Environmental Data

A summary of the thermal environments are presented in Table A-2, whose values are obtained from the Oconee UFSAR, design basis documents, temperature measurements, or are conservatively assumed values. The reference or basis for each temperature is given in the table.

Thermal data obtained from the UFSAR [Reference 10, Table 2-18] is the maximum recorded site temperature of 105°F (40.6°C) which is used for all components exposed to site ambient conditions. Thermal environmental data from design basis documents are specific area design temperatures. Temperature measurements were taken in the Turbine Building and Reactor Building, which reflect temperatures through all seasons. Temperatures for periods when the unit being monitored was shut down were not included. Measurements in the Turbine Building are averaged. Temperatures for the Reactor Building are conservative 99.73% confidence mean values (i.e., 99.73% of the time the actual temperature in the area is at or below the cited temperature).

Temperatures are assumed for Keowee, the Appendix R Warehouse, cable trenches, direct buried and buried conduit and all remaining plant structures and areas. Since no steam pipes or other such heat-generating equipment is inside Keowee, the structures normally remain comfortable, even on hot summer days. Using the recorded site maximum temperature of 105°F (40.6°C) from the UFSAR as the bounding temperature is conservative since the average temperature (due to daily and seasonal variations) is less. The Appendix R Warehouse has no cooling equipment installed but does have roof vents for ventilation. The recorded site maximum temperature of 105°F (40.6°C) from the UFSAR is used for the warehouse and is considered conservative because of the daily and seasonal variations in site ambient temperature. The temperature for cable trench, direct buried and buried conduit environments is conservatively assumed to be 80°F (26.7°C). The remaining plant structures and areas conservatively use the recorded site maximum temperature of 105°F (40.6°C). These include structures such as warehouses, office buildings and outside support structures. Using the recorded site maximum temperature is considered conservative because of the types of structures included and the daily and seasonal variations in site ambient temperature.

Adding additional margin, these bounding temperatures do not take into account that each Oconee unit has run less than 75% of the total time since initial operation [Reference 59]. Therefore, the average area temperatures that influence material aging over a 60-year period are somewhat-to-significantly lower than the bounding temperatures listed in the following table.

Table A-2
Bounding Plant Temperatures

Structure or Area	Specific Area Description and Comments	Bounding Temperature	Reference
Auxiliary Buildings	Concrete around Main Steam Penetrations (Penetration Rooms)	150°F (65.6°C)	[81, Section 10.2.3]
	Areas cooled by the Auxiliary Building Ventilation System	104°F (40.0°C)	[81, Section 10.2.1]
	Spent Fuel Pool Areas	104°F (40.0°C)	[10, Section 9.4.2.1]
	Equipment Rooms (designed for 86°F)	90°F (32.2°C)	[10, Section 16.8.1], [82, Sections 31.1.1, 32.1.1, 33.1.1]
	Control Rooms, Cable Rooms (designed for 74°F)	85°F (29.4°C)	
	Control Battery Rooms	80°F (26.7°C)	[81, Sections 31.2.2 and 33.2.2]
	Areas cooled by the Auxiliary Building Air Conditioning System	75°F (23.9°C)	[81, Section 10.2.2]
Earthen Embankments	Areas exposed to site ambient or direct buried	105°F (40.6°C)	[10, Table 2-18]
Essential Siphon Vacuum Building	All areas	105°F (40.6°C) [Footnote 12]	[83]
Intake Structure	Areas exposed to site ambient	105°F (40.6°C)	[10, Table 2-18]
Keowee Structures	All areas	105°F (40.6°C)	Assumed

12. Oconee calculation, *Estimation of Equilibrium Temperatures for ESV Building due to Natural Draft*, estimates that the bulk temperature without fans running will be 125°F. Normal operation is with the fans running with an estimated maximum of 110°F. The bulk temperatures were estimated using measurements taken at 8 feet above the floor, the cables are routed no higher than 4 feet above the floor and the building ventilation louvers are located at the bottom of the building. Taking into account that the cables are routed at a low level where the cooler air is and the maximum bulk temperature is 110°F, the *average* temperature to which the cables are exposed is conservatively estimated at 105°F.

Structure or Area	Specific Area Description and Comments	Bounding Temperature	Reference
Reactor Buildings	Vessel Head and area around the Control Rod Drives (maintained near 150°F)	175°F (79.4°C)	[84, Sections 31.1.1, 32.1.1, 33.1.1]
	High elevations in Steam Generator Cavities	132°F (55.6°C)	[85]
	Elevation at top of reactor coolant pumps (RCPs)	126°F (52.2°C)	
	Elevation at bottom of RCPs (797'+6”)	116°F (46.7°C)	
Standby Shutdown Facility	Diesel Generator, Switchgear, Pump, HVAC Equipment Rooms	104°F (40.0°C)	[86, Section 30.1.2.2]
	Control, Computer, Battery, Response (CAS) Rooms	72°F (22.2°C)	[86, Section 30.1.2.5]
Turbine Buildings	General areas	105°F (40.6°C)	[87]
Yard Structures	Areas exposed to site ambient	105°F (40.6°C)	[10, Table 2-18]
	Cable Trenches, Buried Conduit	80°F (26.7°C)	Assumed
All remaining plant structures and areas	Areas exposed to site ambient	105°F (40.6°C)	[10, Table 2-18]
	Appendix R Warehouse	105°F (40.6°C)	Assumed [88]
	Cable Trenches, Direct Buried, Buried Conduit	80°F (26.7°C)	Assumed
	all other Class 3 structures	105°F (40.6°C)	Assumed

A.3 Radiation Environmental Data

Design radiation data for normal operation was obtained from the Oconee Nuclear Station Environmental Qualification (EQ) Criteria Manual [Reference 89]. The following table presents a summary of the radiation data pertaining to each structure and area within scope. The values given are conservative maximums and the actual 40-year dose is normally lower (in some cases, much lower). For areas of the plant not listed in the EQ Criteria Manual, it was assumed that the amount of radiation dose is less than the lowest value reported in the EQ Criteria Manual (1×10^2 rads) and, as such, is negligible.

The expected normal dose for 60 years at Oconee is determined by multiplying the current 40-year normal dose by a simple ratio of 1.5 (i.e., 60 ÷ 40). For example, if the normal 40-year dose for a given area is 3×10^4 rads, then the projected normal 60-year dose is 4.5×10^4 rads.

A summary of the projected 60-year radiation dose for plant areas included in the electrical IPA is provided in the following table.

Table A-3
Radiation Dose During Normal Operation

Structure	Area	EQ Criteria Manual [Reference 89]	Maximum 40-Year Normal Operating Dose (rads)	Maximum 60-Year Normal Operating Dose (rads)
Reactor Buildings	Reactor Cavity Steam Generator Cavity	Table EP-1	**3×10^7**	**4.5×10^7**
	El. 797+6 -zone 1 El. 825+0 -zone 1 El. 844+6 -zone 1	Section 7.1.2		
	El. 777+6 -zone 1		1×10^7	1.5×10^7
	El. 777+6 -zone 2		3×10^5	4.5×10^5
	El. 777+6 -zone 3 El. 797+6 -zone 2 El. 825+0 -zone 2 El. 844+6 -zone 2		3×10^4	4.5×10^4
	General areas	Table EP-1		
Auxiliary Buildings	El. 758+0 -zones 5-7 El. 771+0 -zones 1-8 El. 783+9 -zones 1-6 El. 796+6 -zones 1,2 El. 809+3 -zone 2 (PR) El. 822+0 -zones 2,3 (PR)	Section 7.2.2	**1×10^6**	**1.5×10^6**
	Penetration Rooms	Table EP-2		
	El. 758+0 -zones 1-4 El. 796+6 -zones 3,4	Section 7.2.2	1×10^5	1.5×10^5
	El. 809+3 -zone 3 El. 822+0 -zone 1		1×10^4	1.5×10^4
	El. 771+0 -zones 9,10 El. 783+9 -zones 7, 8a-d El. 796+6 -zones 5,6 El. 809+3 -zone 1		1×10^3	1.5×10^3
	El. 838+0 -zones 1a-e (PR) El. 838+0 -zone 2		1×10^2	1.5×10^2
	Cable Spreading Rooms Control Rooms Electrical Equipment Rooms	Table EP-3	Less than 1×10^2	Less than 1.5×10^2
Turbine Buildings	All areas	Table EP-3	**Less than 1×10^3**	**Less than 1.5×10^3**
Earthen Embankments	All areas	Assumed	Negligible	Negligible
Essential Siphon Vacuum Building				
Intake Structure				
Keowee Structures				
Standby Shutdown Facility				
Yard Structures				
All remaining plant structures and areas				

A.4 Moisture

Data regarding moisture was obtained from observations made during plant walkdowns. Although many areas at Oconee could be subjected to a one-time pipe leak, of potential concern for long-term aging are areas where components are subjected to wetting. As used in the DOE Cable AMG [Reference 8, Section 4.1.2.4], the term "wetting" refers to a significant amount of moisture in contact with cable/termination components, such as would be produced by repeated instances of standing water, system leakage/spray, or flooding. Many electrical components included in the aging management review are exposed to outside ambient conditions, which include all forms of precipitation. Areas subject to moisture were identified based on observations and walkdowns by observing existing moisture in the area or by observing areas where there was evidence of components being exposed to moisture in the past. Where evidence of past moisture was found, electrical components in the area that could have been exposed to it were examined for any evidence of degradation. If no evidence of degradation was noted or if the moisture appeared to be a single occurrence, the area was not considered an area subject to wetting. The plant walkdowns provide reasonable assurance that areas subject to moisture (wetting) were identified.

A summary of the areas where moisture was found along with a description is given in the following table.

Table A-4
Moisture Data

Structure or Area	Moisture Found	Description
Auxiliary Buildings	No	No areas subject to moisture.
Earthen Embankments	Yes	Outside areas are subject to precipitation.
Essential Siphon Vacuum Building	No	No areas subject to moisture.
Intake Structure	Yes	Outside areas are subject to precipitation.
Keowee Structures	Yes	Water seepage through a wall in a turbine shaft well.
Reactor Buildings	No	No areas subject to moisture.
Standby Shutdown Facility	No	No areas subject to moisture.
Turbine Buildings	No	No areas subject to moisture.
Yard Structures	Yes	• Outside areas are subject to precipitation. • Cable trench floors are subject to standing water • Buried conduit and manholes may be subject to water collection
All remaining plant structures and areas	Yes	• Outside areas are subject to precipitation. • Cable trench floors are subject to standing water • Direct buried cables are subject to surface water drainage and soil moisture • Buried conduit and manholes may be subject to water collection

B
10 CFR SELECTED QUOTES

Table B-1
Quotes from 10 CFR 54, License Renewal Rule — Selected Parts
[Reference 1]

§54.4 Scope. *(a) Plant Systems, Structures, and components within the scope of this part are —* *(1) Safety-related systems, structures, and components which are those relied upon to remain functional during and following design-basis events (as defined as in 10 CFR 50.49 (b)(1)) to ensure the following functions —* *(i) The integrity of the reactor coolant pressure boundary;* *(ii) The capability to shutdown the reactor and maintain it in a safe shutdown condition; or* *(iii) The capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to the guidelines in §50.34(a)(1) or §100.11 of this chapter, as applicable.* *(2) All nonsafety-related systems, structures, and components whose failure could prevent satisfactory accomplishment of any of the functions identified in paragraphs (a)(1)(i), (ii), or (iii) of this section.* *(3) All systems, structures, and components relied on in safety analyses or plant evaluations to perform a function that demonstrated compliance with the Commission's regulation for fire protection (10 CFR 50.48), environmental qualification (10 CFR 50.49), pressurized thermal shock (10 CFR 50.61), anticipated transients without scram (10 CFR 50.62), and station blackout (10 CFR 50.63).* *(b) The intended functions that these systems, structures, and components must be shown to fulfill in §54.21 are those functions that are the bases for including them within the scope of license renewal as specified in paragraphs (a)(1)-(3) of this section.*
§54.21 Contents of application - technical information. *Each application must contain the following information:* *(a) An integrated plant assessment (IPA). The IPA must --* *(1) For those systems, structures, and components within the scope of this part, as delineated in §54.4, identify and list those structures and components subject to an aging management review. Structures and components subject to an aging management review shall encompass those structures and components --* *(i) That perform an intended function, as described in §54.4, without moving parts or without a change in configuration or properties. These structures and components include, but are not limited to, the reactor vessel, the reactor coolant system pressure boundary, steam generators, the pressurizer, piping, pump casings, valve bodies, the core shroud, component supports, pressure retaining boundaries, heat exchangers, ventilation ducts, the containment, the containment liner, electrical and mechanical penetrations, equipment hatches, seismic Category I structures, electrical cables and connections, cable trays, and electrical cabinets, excluding, but not limited to, pumps (except casing), valves (except body), motors, diesel generators, air compressors, snubbers, the control rod drive, ventilation dampers, pressure transmitters, pressure indicators, water level indicators, switchgears, cooling fans, transistors, batteries, breakers, relays, switches, power inverters, circuit boards, battery chargers, and power supplies; and* *(ii) That are not subject to replacement based on a qualified life or specified time period.* *(2) Describe and justify the methods used in paragraph (a)(1) of this section.* *(3) For each structure and component identified in paragraph (a)(1) of this section, demonstrate that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the CLB for the period of extended operation.*

Table B-2
Quotes from 10 CFR 50.49, Environmental Qualification of Electrical Equipment — Selected Parts
[Reference 39]

§50.49 *(b) Electric equipment important to safety covered by this section is:* *(1) Safety-related electrical equipment.* *(i) This equipment is that relied upon to remain functional during and following design basis events to ensure:* *(A) The integrity of the reactor coolant pressure boundary;* *(B) The capability to shut down the reactor and maintain it in a safe shutdown condition; and* *(C) The capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to the guidelines in §50.34(a)(1) or §100.11 of this chapter, as applicable.* *(2) Nonsafety-related electrical equipment whose failure under postulated environmental conditions could prevent satisfactory accomplishment of safety functions specified in subparagraphs (i) through (iii) of paragraph (b)(1) of this section by the safety-related equipment.* *(3) Certain post-accident monitoring equipment.* *(c) Requirements for (1) dynamic and seismic qualification of electrical equipment important to safety, (2) protection of electrical equipment important to safety against other natural phenomena and external events, and (3) environmental qualification of electrical equipment important to safety located in a mild environment are not included within the scope of this section.*

Table B-3
Quotes from 10 CFR 50 Appendix R, Fire Protection Requirements — Selected Parts Applicable to Oconee Nuclear Station
[Reference 26]

Appendix R to Part 50 — Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979

III. Specific Requirements

F. Automatic fire detection. Automatic fire detection systems shall be installed in all areas of the plant that contain or present an exposure fire hazard to safe shutdown or safety-related systems or components. These fire detection systems shall be capable of operating with or without offsite power.

J. Emergency lighting. Emergency lighting units with at least an 8-hour battery power supply shall be provided in all areas needed for operation of safe shutdown equipment and in access and egress routes thereto.

L. Alternative and dedicated shutdown capability.

1. Alternative or dedicated shutdown capability provided for a specific fire area shall be able to (a) achieve and maintain sub-critical reactivity conditions in the reactor; (b) maintain reactor coolant inventory; (c) achieve and maintain hot standby[3] conditions for a PWR (hot shutdown[3] for a BWR); (d) achieve cold shutdown conditions within 72 hours; and (e) maintain cold shutdown conditions thereafter. During the postfire shutdown, the reactor coolant system process variables shall be maintained within those predicted for a loss of normal a.c. power, and the fission product boundary integrity shall not be affected; i.e., there shall be no fuel clad damage, rupture of any primary coolant boundary, [or] rupture of the containment boundary.

2. The performance goals for the shutdown functions shall be:

a. The reactivity control function shall be capable of achieving and maintaining cold shutdown reactivity conditions.

b. The reactor coolant makeup function shall be capable of maintaining the reactor coolant level above the top of the core for BWRs and be within the level indication in the pressurizer for PWRs.

c. The reactor heat removal function shall be capable of achieving and maintaining decay heat removal.

d. The process monitoring function shall be capable of providing direct readings of the process variables necessary to perform and control the above functions.

e. The supporting functions shall be capable of providing the process cooling, lubrication, etc., necessary to permit the operation of the equipment used for safe shutdown functions.

6. Shutdown systems installed to ensure postfire shutdown capability need not be designed to meet seismic Category I criteria, single failure criteria, or other design basis accident criteria, except where required for other reasons, e.g., because of interface with or impact on existing safety systems, or because of adverse valve actions due to fire damage.

[3] As defined in the Standard Technical Specifications.

C
IDENTIFICATION OF ADVERSE, LOCALIZED ENVIRONMENTS FOR THE INSULATED CABLES AND CONNECTIONS AGING MANAGEMENT PROGRAM

This appendix determines which plant areas are adverse, localized environments that contain in-scope insulated cables. This determination is based on a review of the Oconee operating experience data that was reviewed as part of the license renewal on-site inspections. The full report of these inspections is contained in NRC Inspection Report 99-12 [Reference 60]. The results of the determinations made here will provide the basis for the implementation of the *Insulated Cables & Connections Aging Management Program.*

At the request of the NRC license renewal inspection team, the Duke personnel searched the Problem Investigation Process (PIP) database on the keyword “cables” and identified approximately 500 PIPs on cables and connections from the period 12/93 thru 6/99. The inspection team reviewed summaries of the 500 PIPs and selected 63 PIPs on cables and connections for further review that appeared to be potentially related to cable aging.

During this review, it was recognized that incidents involving insulated cables and connections could be grouped into two sets. Some incidents are clearly design, installation and maintenance related and not relevant to license renewal, while other incidents are clearly aging related and relevant to license renewal. Engineering judgement was used for incidents that fell somewhere between these clear distinctions.

During the initial Duke reviews in 1996 insulated cable and connection incidents were reviewed and identified as being design, installation or maintenance related problems that would not lead to a loss of function if left unmanaged. Due to the existing PIPS on these items there were plans to determine and implement a fix to eliminate the problems. By 1999 these problems still existed (i.e., had not been fixed).

Cables and connections in the design and installation problem areas were aging prematurely. Exact temperature and radiation measurements were not made in the specific areas where the premature aging is occurring and without that it is judgement as to whether the insulated cables and connections will remain functional through the extended period of operation. Duke made one judgement, the NRC made a different judgement. In the heat of what became more of a political and timing issue, Duke accepted the NRC position and created an aging management program.

The lesson learned is that design or installation problems that are not fixed should be considered for aging management unless there is empirical data showing that even as-is, degradation will not cause loss of function if left unmanaged.

REVIEW OF PAST OPERATING EXPERIENCE FOR CABLES & CONNECTIONS

During the inspection most of the items identified in the inspection report were reviewed and categorized by the NRC inspection team along with Duke personnel. The criteria used to create these categories aligns with the Duke process to scope and screen components and the process that identifies applicable aging effects. Most of the items and PIPs identified in the inspection report were found not to involve problems relevant to the aging management review. The additional items and PIPs not categorized during the inspection have been categorized by Duke using the same criteria. All items and PIPs identified in the inspection report are organized into the following groups:

(1) those involving Identification of Cable Insulation Materials

(2) those involving Components Not Subject To An Aging Management Review

(3) those involving Insulated Cables & Connections Serving No License Renewal Intended Functions

(4) those involving Installation Problems, Maintenance Problems, Equipment Problems and Other Non-Aging Problems

(5) those involving Insulated Cables and Connections With No Applicable Aging Effects

(6) those involving Insulated Cables and Connections With Applicable Aging Effects

Each of these areas is discussed in separate subsections along with the items and PIPs pertaining to them.

C.1 PIP Involving Identification of Cable Insulation Materials

Inspection Observation:

E8.5 Review of Open Items – Cable Insulation Materials

"During the ONS license renewal scoping and screening inspection the team determined that the applicant had based its cable material evaluations on the cable types identified in Oconee and Keowee Cable Tabulation Drawings which did not contain all cable types included in the Oconee and Keowee cable databases. Problem Investigation Process (PIP) 99-1737 was written for resolution.

"The applicant completed the Oconee Cable Type Database Review Project which included a review of the following sources to determine all cable type data for Oconee:

Oconee and Keowee Cable Tabulation Drawings
Keowee and Oconee Cable Databases
Duke Power PreFabricated Cable Report
Oconee Vendor Document Index
Oconee Cable Purchase Requisitions and Purchase Orders
Oconee Cable Transfer Records
Oconee 1E Cable Traceability Records
Oconee Cable Specifications
Duke Power Cable Sizing Engineering Criteria Manual
Duke Power Cable Mark Nos. Ampacity Design Criteria Manual.

> "The Oconee Cable Type Database Review Project identified fourteen cable types which were not included in the ONS license renewal cable material evaluation contained in ONS LRA electrical specification OSS-0274.00-00-0006, revision 1, "Oconee Electrical Component Aging Management Review For License Renewal." The fourteen additional cable types contained four materials which had not been previously evaluated in the ONS LRA electrical specification. The four new materials were polypropylene, teflon, tefzel, and vinyl. The Oconee Cable Type Database Review Project data search for additional cable types was a comprehensive review. The applicant performed an engineering evaluation of the four additional materials. The results were contained in Memorandum: W. M. Denny to R. P. Colaianni, dated June 30, 1999, 'Additional Cable Insulation Materials at Oconee.' The results of the review project were that the original conclusions of the ONS LRA electrical specification OSS-0274.00-00-0006, revision 1, were not changed.
>
> "The team verified that the three cable mark number types identified during the scoping and screening inspection as not being listed in the ONS and Keowee cable tabulation drawings were included in the review project database. The team reviewed the material evaluation for the additional cable materials and determined that the new materials were evaluated consistent with the process performed for the original cable material evaluations included in electrical specification 0SS-0274.00-00-0006, revision 1. The team concluded that the new material evaluations did not identify any cable material applications which were more limiting than the previous evaluations or that would be unsuitable for the period of extended operation. The applicant had completed the evaluation of the additional cable types but the results of the evaluations contained in the June 30, 1999, memorandum have not yet been incorporated into the ONS LRA documents. The Oconee and Keowee cable tabulation drawings have not yet been updated with the new data and PIP 99-1737 remains open."

- **PIP 99-1737** reported that the Oconee and Keowee cable tabulation sheets (drawing series OEE-14 through OEE-14-14 and KEE-40-2 through KEE-40-6) were not up to date. The PIP was resolved by performing a study of cable types, updating the cable databases with the information and revising the cable tabulation sheets as historical documents that do not reflect the as-built plant. The resolution included updating Table 7-1 to include the additional insulation materials and applications.

C.2 Items & PIPs Involving Components Not Subject To AMR

Several items and PIPs identified in the inspection report dealt with components that are not subject to aging management review. These are detailed below.

Uninsulated Ground Conductors

- **PIP 97-1627** reported oxidation on an uninsulated hotwell motor grounding conductor. Investigation determined that the oxidation was only on the surface of the conductor and no corrective action involving the conductor was required. This PIP deals with an uninsulated ground conductor and not an insulated cable or connection. This PIP was categorized as "not in scope" during the license renewal inspection.

Abandoned Cables

> **Inspection Observation:**
> "Numerous electrical cables have been designated as abandoned, with cut off ends hanging out of cable trays not tagged or marked "deleted" after being abandoned."
>
> "Similar to the Reactor building, numerous electrical cables have been designated as abandoned without clear marking."

The observation is correct that numerous cables have been taken out of service, cut back and left abandoned in cable trays. All the cables seen by the ONS personnel on the walkdown or pointed out to him by the inspectors in the Unit 1 Reactor Building did have tags and were not hanging out of trays. Some abandoned cables in the Turbine Buildings did not appear to be tagged for identification. Regardless, abandoned cables are not connected to any equipment, serve no license renewal intended function and are not within the scope of the license renewal review.

Floor Wax and Wax Stripper on Transformer CT-5 Power Cables

Inspection Observation:
"The applicant earlier identified a potential problem with floor wax and wax strippers getting on cables potentially resulting in cable aging due to contact with chemical stressors."

Cables used to connect Transformer CT-5 (part of the power connection to the Lee Combustion Turbines) with the rest of the power system are routed below some floor grating in the Turbine Building. These cables are constructed with insulation covering the conductors, covered by a jacket, covered interlocked armor and an overall jacket. When first identified during an inspection, it was theorized that over the years the top of the cable may have been exposed to wax strippers along with floor wax. Wax and accumulated dust now cover the tops of these cables but no damage to the overall jacket was observed and the wax covering now adds additional protection to the cable jackets. No applicable aging effects were identified. In addition, although included within the scope of review of electrical components, NRC Inspection Report 99-11 (May 24, 1999) confirmed that systems, structures, and components (including these cables) required for the Lee Combustion Turbines to provide an alternate source of power to Oconee do not serve any license renewal intended functions. Therefore, no aging management is required since there is no license renewal intended function to maintain.

Hydrogen Recombiner Cables

- **PIP 93-1077** was written to repair cables on the portable hydrogen recombiner. Consistent with the electrical methodology for component boundaries, these cables were supplied with and are an integral part of the hydrogen recombiner, are maintained as part of the hydrogen recombiner and are not separate cables to be included in the review of insulated cables and connections. PIP 93-1077 during the routine maintenance of the hydrogen recombiner, which demonstrates that the cable is maintained as a part of the hydrogen recombiner. Aging effects of the hydrogen recombiner are not applicable to the insulated cables and connections review.

GE "Jones Plug" Connectors

- **PIP 95-1387** was written because the flex cable at the bottom plate to valve 1MS-0043 was broken. The connector type is known as a Jones Plug, is a very old design and was original equipment supplied by General Electric (GE). Since originally installed, normal wear required the connector to be repaired several times but the connector shell was now deforming and allowing the cable to pull loose from the connector housing. This connector was replaced with a splice to eliminate the problem. The spliced cables are for limit switches and thermocouples on the feed pump turbines. These cables are nonsafety-related and serve no license renewal intended functions.

Fuel Handling Bridge Cables

Inspection Observation:
"Cables in the area above and adjacent to the reactor core that supply power to the fuel handling bridges were badly damaged from exposure to elevated temperature, possibly radiation, and mechanical stress to the cables as a result of movement of the two refueling bridges."

The fuel handling bridge is seismically designed but no electrical equipment on the bridge is safety-related or relied upon to remain functional during or following any design basis event and are not relied upon for any of the license renewal scoping regulated events. These PIPs were categorized as "not in LR scope" during the license renewal inspection.

- **PIPs 96-1042 and 96-1044** reported that the sheathing on the fuel handling bridge cables was deteriorated. In June 1999 the Unit 1 fuel handling bridge cables were observed by the NRC license renewal inspectors during an outage. During the same outage, one of the two fuel handling bridges was removed and all cables on the remaining fuel handling bridge were replaced. These cable replacements are occurring on all three units.

Cables Around the Control Rod Drive Service Structure

Each of the PIPs involve cables installed in the area of the CRD service structure. All cables installed in the area of the CRD service structure are nonsafety-related and serve no license renewal intended functions. Insulated cables and connections in this area are not included in the aging management review.

- **PIP 97-1236** cleaned corrosion from a control rod drive (CRD) connector and was categorized as "connector corrosion" during the license renewal inspection.
- **PIP 97-2455** theorized that cable degradation may be occurring so the cables were tested and found to be functional.
- **PIP 97-3356** reported the failure of two CRD service structure air temperature thermocouples. The problem was isolated to portions of the system that included the cable but neither the failed component nor the cause of the failure were documented. No description of jacket or insulation degradation was included in the PIP. This PIP was categorized as "not in LR scope" during the license renewal inspection.
- **PIP 97-4303** reported thermocouple cables located on the CRD head service structure had become brittle. The cables were to be replaced during a subsequent outage. This PIP was categorized as "not in LR scope" during the license renewal inspection.

C.3 PIPs Involving Installation, Maintenance, Equipment And Other Non-Aging Problems

Several items and PIPs identified in the inspection report dealt with installation, maintenance, equipment and other non-aging problems. These are detailed below.

INSTALLATION PROBLEMS

- **PIP 97-0356** reported that the armor of cables leaving a reactor coolant pump connection box were pulling away from the box connectors due to the weight of the cables. This PIP was categorized as “inadequate support” during the license renewal inspection, which is an installation problem.
- **PIP 96-0605(1)** reported that the cable to valve 2HPE-10 is inside pipe insulation at Turbine Building Column L34. No cable jacket degradation was noted, only the physical plant configuration. The electray was pulled away from the pipe to provide an air space between the pipe and electray. This PIP was categorized as an “installation problem” during the license renewal inspection.
- **PIPs 96-0605(2) and 96-0605(5)** reported two instances pipe insulation was partially installed around a conduit. The conduit identified in PIP 96-0605(2) was found to be empty (i.e., no cables inside). The pipe insulation was reinstalled to eliminate contact with the conduit identified in PIP 96-0605(5). These PIPs were each categorized as an “installation problem” during the license renewal inspection.
- **PIP 96-0605(6)** reported part of a Turbine Building electray routed inside some pipe insulation at small valve. No cable jacket degradation was noted, only the physical plant configuration. This PIP was categorized as an “installation problem” during the license renewal inspection.
- **PIP 96-2513(RB1-13)** reported that the cable to valve 1CC-3 drapes and touches the top of the large pipe. The pipe insulation is separated at the top exactly at the point the cable touches. The separation about 3" inches and there’s about an 8" area where the cable jacket has deteriorated enough that it has all fallen off and the exposed armor is discolored. This PIP was categorized as an “installation problem” during the license renewal inspection.
- **PIP 96-2513(RB1-34)** reported that a braided armor cable is draped across a large insulated pipe next to Penetration WC-13. This PIP was categorized as “installation problem” during the license renewal inspection.
- **PIP 96-2516(RB1-5)** reported that the braided armor around an instrumentation cable against the shield wall is damaged due to a severe bend in the cable. This PIP was categorized as “installation problem” during the license renewal inspection.
- **PIP 96-2519(RB3-4)** reported there is a violation of bending radius on two small cables in a vertical run cable tray. This PIP was categorized as “installation problem” during the license renewal inspection.

MAINTENANCE PROBLEMS

- **PIP 96-0605(3)** reported that a conduit next to insulated valve shows conical shaped heat degradation. The insulation around the valve was improperly installed with a gap allowing heat to stream in the direction of the conduit. This PIP was categorized as “maintenance problem” during the license renewal inspection.
- **PIP 96-2415** reported that leaking fluid or cooling coil condensate from Reactor Building auxiliary cooling unit ‘B’ is producing corroding electrical and mechanical components

located below it. This PIP was categorized as “maintenance issue” during the license renewal inspection.

- **PIP 96-2499** reported Turbine Building roof leaks and structure joint leaks. This PIP was categorized as “Turbine Building roof leaks” during the license renewal inspection.
- **PIP 96-2514(RB2-4)** reported the outside jacket a cable connected to safety-related containment isolation valve 2-PR-9 has been partially melted and is scarred. The scar is in direct line with a pipe weld. This PIP was categorized as “welding maintenance problem” during the license renewal inspection.
- **PIP 96-2519(RB3-6)** reported that a metal barrier in the cable tray separating two large gray cables from the other cables in the tray is knocked down for about 10 feet of its length. This PIP was categorized as “maintenance issue” during the license renewal inspection.
- **PIP 97-4558** reported that the armored cable terminator for cable 1EXS1203a (control cable for 1LP-1) was broken at the threads. There is no normal aging effect that could cause this type of damage. This PIP was categorized as a “maintenance issue”.
- **PIP 98-2538** reported rainwater intrusion into the Turbine Building. This PIP was categorized as a “maintenance issue”.
- **PIP 98-3685** reported that during cleanup work a workman bumped into the power cable connector for 2LWD-1, which broke at the connector. An arc was reportedly seen and a snap was heard during the incident. This PIP was categorized as “damaged by worker” during the license renewal inspection.
- **PIP 98-6050** reported that water was dripping on top of electrical terminal cabinet ORWIG located in the south end of the Turbine Building basement. This water was dripping from an electrical penetration on the South Turbine Building wall (presumably rain water from outside), being carried by the angle iron supports for the cable trays to the top of the cabinet and making its way into the cabinet. This PIP was categorized as “maintenance issue” during the license renewal inspection.

EQUIPMENT PROBLEMS

- **PIP 96-0605(4)** reported that flex conduit to LS-62 at valve 2AS-10 shows severe heat damage. The source of the heat was the limit switch, probably caused by a malfunction. This PIP was categorized as “equipment problem” during the license renewal inspection.
- **PIP 96-2515(RB3-13)** reported that the braided armor on an instrumentation cable has deteriorated to the point that it has fallen off the insulation. This deteriorated region is about 2 feet in length. The insulation is also cracked. Other adjacent cables showed no similar damage. This PIP was categorized as “could be equipment problem” during the license renewal inspection.
- **PIP 97-2994** reported that the computer point for an Reactor Building cooling unit thermocouple read intermittently. Diagnosing pointed to possible cable problem. Upon preparing to route new cable per this minor modification it was found the pin connector at the Penetration Room recessed. The pin connector was fixed. The computer indication was restored. The new cable was not needed. This PIP was categorized as “loose equipment pin connector”.

- **PIP 98-5254** reported that several cables in a Reactor Building cable tray have what appears to be severe armor braid damage with the sub-jacket brittle and falling off of the cable exposing either a shield (braided) or the outside conductor for a coaxial cable. Only three visible cables in about a three foot section show this type damage and it seems to be confined to a particular cable type. There is one gray cable in this section of tray but it shows no visible damage. All other cables are black and non-safety. No operability concerns exist. This PIP was categorized as “probable equipment problem”.
- **PIP 98-5591** reported that several cables on the west side of the Reactor Building have rusted braided armor. The braided armor on two cables is corroded through with the internal jacket on one cable exposed (the jacket is in good condition). These cables in this section of tray are all nonsafety and black. This problem is similar to that reported in PIP 98-5254 except for a different location. This PIP was categorized as “probable equipment problem”.

Other Non-Aging Problems

- **PIP 94-0447** reported valve discharge draining onto a cable tray. Replaced transmitter, potted new cable fittings to keep water out of the transmitter and rerouted drain to prevent future damage to cable, cable tray and transmitter. This PIP was categorized as “design problem, valve discharge” during the license renewal inspection.
- **PIP 96-0605(7)** reported that a electray with Blue cables had come apart at a bolted joint. The electray sections were reattached. This was not an aging effects concern. This PIP was categorized as “no aging” during the license renewal inspection.
- **PIP 96-2518(RB2-21)** reported that there are two cable trays that contain a few spliced cables. One tray is at shoulder lever and the other is about one foot above the floor grating. This PIP was categorized as “not aging problem” during the license renewal inspection.
- **PIP 96-2518(RB2-28)** reported that a cable from the bottom of a terminal box mounted on RC pump 2A1 goes into a 16" wide cable tray. There are a few cable splices in the tray. One splice has a splice bolt protruding through the splice insulation and the metal is exposed. This PIP was categorized as “not aging problem” during the license renewal inspection.
- **PIP 96-2519(RB3-8)** reported that a nonsafety cable splice was next to an orange cable in an electray. The orange cable goes to safety-related RC pressure transmitter PT-20P, RC3B-PT2. This PIP was categorized as “separation issue” during the license renewal inspection.
- **PIP 96-2519(RB3-14)** reported that a metal barrier in a cable tray that separates a single black cable from other cables in the tray is mashed down over the single cable. A joint in the barrier has separated in this area and also two cables cross the barrier and join the single cable. This PIP was categorized as “no aging” during the license renewal inspection.
- **PIP 96-2523** reported that an inspection of the electrical cables in the Reactor Building identified several cables damaged due to various causes. Separate PIPs were written to do further evaluations on cable problems caused by improper installation and by external thermal heating. This PIP documents the rest to the inspection findings which will be corrected by Work Request where applicable. No past or present inoperabilities were identified based on the judgement of the inspectors. The problems identified in this PIP were judged not to be aging problems. This PIP was categorized as “not aging issues” during the license renewal inspection.

- The following PIPs were identified in NRC Inspection Report 99-12 as “Non-Aging Cable/Connector PIPs” and are not reviewed further.

94-0435	96-1676	97-0359	97-0430	98-0957	98-1615	98-2533
98-3270	98-3808	99-0288	99-0354	99-0478	99-0530	99-0787
99-1153	99-1179	99-1439	99-1495	99-1585	99-2287	99-2621
99-2676	99-2679	99-2680	99-2688	99-2800	99-2857	99-2946

C.4 PIPs Involving Insulated Cables & Connections With No Applicable Aging Effects

Several items and PIPs identified in the inspection report dealt with insulated cables and connections with no applicable aging effects. These are detailed below.

Standing Water in the CT-5 Cable Trench

Inspection Observation:
“The sump pump located in the CT-5 cable trench in the turbine building has not operated properly for many years. A portable sump pump had been installed, but was ineffective in removing the water. Currently, water is removed by a rubber hose to the Unit 3 Turbine Building sump via siphon action. The cables in the trench were coated with mud and silt indicating that they have been frequently submerged.”

“Following the July 15, 1999, walkdown of the Turbine Building in which the inspectors observed that some cables in the cable trench are subjected to standing water or submergence on occasion, the applicant provided a letter dated July 26,1999, from an industry cable consultant to an applicant engineer which concluded that the types of materials typically used for cable jackets and insulation at Oconee can be subjected to submergence without a deterioration of the materials. While industry submergence tests typically last for 14 days, the inspectors noted that the effects of long-term submergence on the insulation resistance is unknown. Currently, the applicant does not periodically measure insulation resistance values for cables in trenches that have been subjected to standing water or submergence. Therefore any insulation degradation that may be occurring on cables that have been repeatedly submerged is unknown.”

“… standing water or submergence in cable trenches …”

The accumulation of water in the CT-5 cable trench was previously identified and entered into the station corrective action process in two PIPs. Where the water collects in the trench is designed to be the low point for the system of cable trenches carrying cables exiting the west side of the Auxiliary Building. During heavy rains, water that does not drain out of the cable trenches in the yard runs to this low point in the cable trench system and collects until drained. This cable trench low point in the Auxiliary Building is inspected for water collection twice a day as part of the operator rounds and any accumulated water is removed as stated in the observation.

Cables routed in outside cable trenches are covered with an overall PVC jacket and are designed to be exposed to intermittent wetting during a heavy rain. Rainwater enters cable trenches around the concrete trench covers, which are not designed to be seal out rainwater. As described in Section 3.6.3.1.2 of Exhibit A of the Application [Reference 62] (replaced via Response to RAI 2.6-1 provided by Duke letter dated February 17, 1999) the potential aging effect for cables exposed to moisture is the creation of water trees and applies only to medium-voltage cables. The insulated cables and connections aging management program identifies program actions if medium-voltage cables are exposed to significant voltage and significant moisture. Significant moisture exposure is defined as periodic exposures to moisture that last more than a few days (e.g., cable in standing water). Periodic exposures to moisture that last less than a few days (i.e., normal rain and drain) are not significant.

The cables routed in the low point of the trench system in the Auxiliary Building are the same cables that are routed in the cable trenches running through the yard west of the Auxiliary Building. Since the cable trench low point in the Auxiliary Building is inspected for water collection frequently, these cables are exposed to water intermittently, just as these same cables are exposed to intermittent rainfall in the yard trenches. Therefore, cables in the CT-5 cable trench are not exposed to significant moisture as defined in the program and the related aging effects are not applicable to the cables.

- **PIP 94-1680** reported that the CT-5 cable trench has water intrusion problems. The problems identified in this PIP were judged not to be aging problems. This PIP was categorized as "moisture/water collection" during the license renewal inspection.
- **PIP 95-0058** reported that during times of heavy or sustained rainfall, the portion of the CT-5 cable trench which comes through the west wall of the Turbine Building accumulates water.

BORIC ACID CONTACT WITH CABLES

Inspection Observation:
"Rust was noted on a number of cables with flex-conduits and braided metal jackets. The applicant explained that the rust resulted from contact with boric acid solution dripped or sprayed on them during plant operation or outages. The metal jacket prevents visual observation of the insulation so the potential effects from boric acid on the cable insulation could not be observed. The applicant was requested to evaluate the potential effect of boric acid on cable insulation."

"Following the June 22,1999, walkdown in the Unit 1 Reactor Building, the applicant was requested to evaluate the potential effect of boric acid solution on cable insulation. The inspectors were shown a letter dated 7/22/99, from an industry cable consultant to an applicant engineer stating the applicants conclusion that with the exception of Kapton insulation and Nylon (connectors and terminal blocks) boric acid solution will not have a negative effect on the cable insulation materials used at ONS. The inspectors agreed with the applicant's conclusion with the exception of potential boric acid ingress into cable connector pins which can result in connector failure due to shorting."

- **PIP 97-0102** reports that drain valve 1BS20 is left open during operations. This drain discharges onto the reactor coolant pump cables and allows a build up of boron and moisture, which is corroding the cable armor. The effects of borated water leakage on the underlying jacket and conductor insulation materials is known and as pointed out during the inspection does not degrade the materials. There are no applicable aging effects caused by borated water leakage on cables.

C.5 Items & PIPs Involving Insulated Cables & Connections With Applicable Aging Effects

Several items and PIPs identified in the inspection report are related to what are considered applicable aging effects. These are detailed below.

Cables Installed Over Feedwater Lines In The Reactor Buildings

Inspection Observation:
"A cable tray on the Unit 1 East Side second level showed severe signs of thermal degradation to most of the cables in the tray. The cables appeared to have been damaged from heat generated from a 16" feedwater line located directly beneath the cable tray. ONS personnel stated that this condition exists at the same location in all three operating units with Unit 3 cables exhibiting the most degradation. ONS personnel indicated that they had no reason to question whether the cables were still functional."

These cables and their condition were noted by maintenance personnel and during a cable inspection in 1996 and are documented in several PIPs. This is a known problem that has been reviewed. As part of the corrective action process, the cables in the tray were tested and all cables were functional. The inspector observation that, "ONS personnel indicated that they had no reason to question whether the cables were still functional" was correct but incomplete in that the ONS personnel stated that he had no question whether the cables were still functional because the ONS personnel knew that the cables had been functionally tested as part of the PIP resolution.

- **PIP 96-2513(RB1-31)** reports that heat deteriorated cables were found in a tray that runs directly above a large insulated pipe. The deterioration is cone shaped; two to three feet wide toward the outer wall and decreases going toward the shield wall. The tray is located in the Unit 1 Reactor Building at elevation 825'+0", second floor, pipe in penetration #27, near valve FDW-269.
- **PIP 96-2514(RB2-2)** reports that heat deteriorated cables were found in a tray that runs directly (~2") over a large insulated pipe. There is one braided armor cable strapped to the outside of the cable tray that has deteriorated to the point that the cable armor and jacket are falling off. The cable armor on the other cables in the tray is corroded and the cables are somewhat stiff. The tray is located in the Unit 2 Reactor Building at elevation 825'+0" near feedwater pipe mechanical penetration #27.
- **PIPs 96-2515(RB3-1)** and **98-5144** report that heat deteriorated cables were found in a tray that runs directly over a 16" insulated feedwater pipe. One cable jacket is split, the heat seems to have affected a wider area towards the outer wall. The tray is located in the Unit 3 Reactor Building near column C17, east, second floor pipe chase, between cable tray junction points 5335 and 5336.

CABLES ROUTED CLOSE TO THE STEAM GENERATORS AND PRESSURIZERS IN THE REACTOR BUILDINGS

Inspection Observation: "…thermal aging in the steam generator cavity and pressurizer areas of the Reactor Building;…"

- **PIP 96-2513(RB1-11)** reported that the braided armor and insulation on two instrumentation cables are very deteriorated. The cables go to small connection boxes near a Unit 1 steam generator.
- **PIP 96-2513(RB1-16)** reported that several cables coming from bottom connections to a terminal box on RC pump 1B2 (near the top) show signs of heat deterioration. These cables also run next to the steam generator insulation.
- **PIP 96-2514(RB2-20)** reported that several cables coming from bottom connections to a terminal box on RC pump 1B2 (near the top) show signs of heat deterioration. These cables also run next to the steam generator insulation.
- **PIP 96-2514(RB2-22)** reported that several cables in a tray near the Unit 2 pressurizer show signs of heat deterioration. The area is 2'-3' from the pressurizer.
- **PIP 96-2514(RB2-27)** reported that an instrument cable mounted on the wall near the Unit 2 pressurizer is fairly stiff and should be replaced.
- **PIP 96-2516(RB1-7)** reported that there are several splices in a cable tray next to the Unit 1 pressurizer. The configuration is the same as reported in PIP 96-2514(RB2-27) except that the presumably damaged cables have been spliced and a metal heat shield has been placed in the tray to block heat from the pressurizer that apparently caused the heat damage.

HEAT-SHRINK ON PRESSURIZER HEATER CONNECTORS IN THE REACTOR BUILDINGS — APPLICABLE ONLY FOR SSF CONTROLLED HEATER CABLE CONNECTORS

PIPs: 96-2513(RB1-8), 96-2514(RB2-23)

Inspection Observation: "…boric acid contact with Kapton insulated pressurizer heater cables…" "Additionally the team learned that ONS performs cable megger checks of pressurizer heater cables at each refueling outage and that there have been repeated problems with the cable to heater connectors." "PIPs reported moisture and boric acid noted near the pressurizer and this can have an aging affect on Kapton insulation which is used in the pressurizer heater cables."

- **PIP 96-2513(RB1-8)** reported that heat shrink used on large connectors at the Unit 1 pressurizer are deteriorated. The heat shrink covers about 8" of the large stainless steel braided armor cables and the large metal connectors. The deterioration is most pronounced for the material covering the metal parts of the connectors.
- **PIP 96-2514(RB2-23)** reported that heat shrink used on large connectors at the Unit 2 pressurizer are deteriorated. The heat shrink covers about 8" of the large stainless steel braided armor cables and the large metal connectors. The deterioration is most pronounced for the material covering the metal parts of the connectors.

KEOWEE-OCONEE 13.8KV DIRECT BURIED CABLES

Inspection Observation:
"… potential degradation of the 13.8kV underground feeder cable from Keowee to the plant (1 mile) based on recent partial discharge test results."

"During the inspection the team learned that the applicant has performed several partial discharge tests on the Oconee/Keowee buried underground cables to attempt to detect any cable insulation degradation. The inspectors discussed the test methods and results with the applicant engineers. The partial discharge test is a new experimental non-destructive test method where step increasing voltage is applied to a cable conductor while electronically monitoring for an indication of insulation weakness at the applied voltage level. On August 5, 1997, a partial discharge test to a 9kV voltage level phase to ground, which is 113% of nominal operating voltage, was performed with no indications of partial discharge detected. On March 11, 1999, another partial discharge test to 16kV, which is >200% of operating voltage was performed. This time partial discharge was observed on four of the six cables with the lowest indication observed at 113.5% of operating voltage. At the close of this inspection, the inspectors and the applicant were unsure if the results of the first two tests indicated cable insulation deterioration due to aging. The inspectors were told that the applicant was procuring replacement cable as a contingency for future replacement needs.

"Subsequent to this inspection, on August 6, 1999, another partial discharge test was performed to 16kV and the reported results were similar to the results of the second test. The lowest partial discharge indication was 121.1% observed on the same cable which was lowest in the second test. Therefore, these test results did not indicate a negative trend of cable degradation."

As stated in the inspection report these tests do not indicate a negative trend for the condition of the conductor insulation. The insulated cables and connections aging management program identifies program actions for medium-voltage cables exposed to significant moisture and significant voltage. Significant voltage exposure is defined as being subjected to system voltage for more than twenty-five percent of the time. The 13.8kV direct-buried cables are energized less than 20% of the time. Therefore, these cables are not exposed to significant voltage and the aging effects are not applicable. Regardless, these cables will be included in the set of cable to be evaluated for inclusion in the *Insulated Cables And Connections Aging Management Program*.

- **PIPs 95-0611** and **95-0947** report the results of tests performed on the 13.8kV Keowee-Oconee direct buried cable.

HPSW PUMP MOTOR CABLE FAILURE

Inspection Observation:
"There was a failure of a 4kV cable to the B High Pressure Service Water Pump which occurred in 1980 where the cable had minor jacket damage and there was water in the buried conduit containing the cable. Moisture was stated as the most likely cause of the failure combined with the jacket damage."

The 4160V high pressure service water (HPSW) pump motor cable is installed in embedded conduit and in 1980 experienced a failure during motor testing. The HPSW pump motor cables are single conductor with EPR primary insulation, covered with a copper shield, galvanized steel armor and an overall PVC jacket [Reference 90]. During a routine test in 1980, the cables to HPSW pump motor "B" were declared inoperable and replaced [Reference 91]. The following is from the incident investigation report.

> **Incident Investigation Report B-953, January 17, 1980 [Reference 91]**
> *…When S.M.S. electricians began tracing the cable route in preparation for pulling out the old cable, they discovered water in the conduit in which the cable had been pulled. They also discovered water and trash covering the cable where it passed thru a couple of manholes. The water most likely entered the conduit from the manholes due to the manhole drains being stopped up.*
>
> *The cables were inspected after they were pulled out and there were no visible signs of insulation degradation. Moisture is the most likely cause of the problem. It could have been absorbed thru a small nick in the cable jacket, or it could have entered the insulation when the cables were first pulled. … it appears that the problem occurred … as a result of excessive exposure to moisture combined with a problem on the cable jacket.*

The manholes were cleaned and water in them was drained out before the cables were replaced and periodic manhole inspections are performed to maintain proper drainage. As stated in the report, the problem was likely caused by "Moisture … absorbed thru a small nick in the cable jacket, or it could have entered the insulation when the cables were first pulled." Both of the named causes (nick in the jacket and water entering when first pulled) are either manufacturing or installation problems and are not related to normal aging. Unless improperly installed or otherwise damaged during installation, the overall PVC jacket precludes moisture from contacting the primary cable insulation. Moisture in contact with the outer jacket does not present a moisture concern for these power cables. The HPSW pump motor cable was replaced and no other such failures have occurred. The LER describing this event attributed the failure to damage of the jacket during installation or improper installation during which water was allowed to enter the end of the cable and travel underneath the jacket.

Regardless, due to the Davis-Besse cable failure (as explained in Section 0, page 7-33), this incident is used as evidence that aging effects for medium voltage cables caused by significant moisture and significant voltage exposure are applicable.

Cable Manholes with Medium-Voltage Cables

After reviewing the LER for the HPSW pump motor cable failure, cable manholes were inspected, which resulted in the following PIP.

- **PIP 98-2483** reported that manholes were inspected and the following types of things were found. Dirt and water were found in the bottom of the manholes, which partially or completely covered some of the cables.

D
REFERENCES

1. Federal Register, Vol. 60 No. 88, Monday, May 8, 1995, (60 FR 22461), Final Rules, 10 CFR Part 54; Includes the Statement of Considerations (SOC) for the Final Rule.
2. February 8, 1999, letter from Christopher I. Grimes, Project Director, License Renewal Project Directorate, NRR, to Duke Energy Corporation, Subject: Trip Report: Oconee Nuclear Station Scoping and Screening Methodology Site-Visit.
3. February 17, 1999, letter from W. R. McCollum, Jr., Site Vice President, Oconee Nuclear Station, to U.S. NRC Document Control Desk, Subject: License Renewal, Response to Requests for Additional Information, Oconee Nuclear Station.
4. "A Standardized Procedure for Evaluating the Relative Thermal Life and Temperature Rating of Thin-Wall Airframe Wire Insulation," David K. Elliot, IEEE Transactions on Electrical Insulation EI-7(1), March 1972, pp. 16-25. Citation 461 in "A Review of Equipment Aging and Theory and Technology," EPRI NP-1558, September 1980, Electric Power Research Institute.
5. *Webster's New World Dictionary of American English*, Third College Edition, Copyright 1988 by Simon & Schuster, Inc.
6. EPRI TR-100516, *Nuclear Power Plant Equipment Qualification Reference Manual*, Published by Electric Power Research Institute (EPRI), 1992.
7. EPRI BR-101747, Common Aging Terminology, A Glossary Useful for Understanding and Managing the Aging of Nuclear Power Plant Systems, Structures, and Components, February 1993.
8. SAND96-0344, *Aging Management Guideline for Commercial Nuclear Power Plants* - *Electrical Cable and Terminations*, September 1996, Prepared by Ogden Environmental and Energy Services under contract to Sandia National Laboratories for the U. S. Department of Energy, in cooperation with the Electric Power Research Institute.
9. NEI 95-10 (Revision 0), *Industry Guideline for Implementing the Requirements of 10 CFR Part 54* - *The License Renewal Rule*. **NOTE: Later revisions of this document are now available. This revision is used since there were no later revisions at the time the Oconee work was completed.**
10. UFSAR, *Oconee Nuclear Station Updated Final Safety Analysis Report*.
11. February 17, 1999, letter from W. R. McCollum, Jr., Site Vice President, Oconee Nuclear Station, to U.S. NRC Document Control Desk, Subject: License Renewal, Response to Requests for Additional Information, Oconee Nuclear Station.
12. *Location of Event Mitigation Equipment*, Prepared by G. D. Rankin, Duke Engineering & Services, January 21, 1999. This study was conducted for both civil and electrical disciplines as a validation of the scoping by structure. The NRC staff had many concerns with scoping electrical components based on the classification of structures. This was a huge stumbling block for the staff and it appeared to be such an impediment to the process that the electrical scoping process was changed to a more bounding approach (i.e., all plant electrical component are included in the review unless they are specifically scoped out) and this study was performed to validate that all in-scope electrical components were supported by in-scope structures.

13. WD-SRP-LR, *Standard Review Plan for the Review of License Renewal Applications for Nuclear Plants*, Working Draft published September 1997, U. S. Nuclear Regulatory Commission. **NOTE: Later revisions of this document are now available. This revision is used since there were no later revisions at the time the Oconee work was completed.**

14. Determination of Aging Management Review for Electrical Components, September 19, 1997, letter from Christopher I. Grimes, Director, License Renewal Project Directorate, NRC, to Douglas J. Walters, Nuclear Energy Institute.

15. License Renewal Issue No. 98-0016, "Aging Management Review of Fuses", April 27, 1999, letter from Christopher I. Grimes, Chief, License Renewal and Standardization Branch, NRR, to Douglas J. Walters, Nuclear Energy Institute.

16. The Oconee *Quality Standards Manual* defines the quality assurance levels and identifies safety-related components.

17. IEEE 100-1984, *The IEEE Standard Dictionary of Electrical and Electronics Terms*, Institute of Electrical and Electronics Engineers, Inc.

18. *Instrumentation*, by Franklyn W. Kirk and Nicholas R. Rimboi, Third Edition, Copyright 1975 by American Technical Publishers.

19. **Duke Power Electrical Expert Component List Review:** Starting in late December, 1996, and continuing through January, 1997, individuals with knowledge of the Oconee electrical systems were asked to review a list of electrical components. The stated purpose of the review, as given to the reviewers, was to make sure that the list contained all types of electrical components installed at Oconee. The list of electrical components that was given to these individuals to review was generated from various sources including NEI 95-10 Rev. 0, Appendix B, and Oconee station one-line power system drawings. The initial list was routed to individuals in the Oconee Electrical Systems each group and the Nuclear General Office (NGO) Electrical Systems. Comments were received from all individuals by phone, interoffice mail, or email note. Comments included new component types to add, corrected component names, and additional lists to review for components (e.g., directives, work management system, equipment databases). The comments and new list reviews were incorporated into a revised electrical component list.

20. **Review of Electrical Component Functions and Groupings, Information from Mike Miller, Oconee Nuclear Station:** In late June and early August 1997 I had telephone conversations with Mike Miller who has an extensive background in I&C components. I was getting his input regarding electrical component functions. About the beginning of August I faxed to Mike my latest draft table of the electrical component grouping based on functions. Mike reviewed the draft and provided substantive comments during a telephone conversation I had with him on August 7, 1997. His comments were incorporated in the next draft of the table.

21. **License Renewal Electrical Working Group:** Starting in mid February, 1997, and continuing through September, 1997, individuals with electrical backgrounds from other nuclear utilities interested in license renewal and involved in the NEI License Renewal Task Force were consulted regarding the Oconee electrical component list. The purpose of the review by these individuals was to look at the Oconee list of components with the following items in mind:
    * Identify additional component types not already on the list
    * Compare the Oconee list with the NEI 95-10 Rev. 0 Appendix B list
    * Identify component functions for components not yet designated as "passive" or "active" in NEI 95-10
    * Combine types of electrical components into logical groups
    * Make a active/passive determination for all electrical components in the list

    The list of electrical components given to these individuals to review was the electrical component list finalized after the reviews by Oconee and NGO personnel. The following individuals from other utilities were involved in these reviews:

* Boris Gan	GPU Nuclear
* Paul Thomas	PECO
* Jeff Mulvehill	Southern Nuclear
* Carl Yoder	BG&E

* Tony Ploplis Entergy

The reviews by these individuals included meetings (February 19, May 20, September 16), a telephone conference (February 25), and several individual telephone conversations.

22. Memo To File, 3/27/98, Oconee & Keowee PRA Failures, Uninsulated Ground Conductors, Information from P. M. Abraham, NGO Severe Accident Analysis. I had a conversation with P. M. Abraham regarding failures included in the Oconee and Keowee PRAs. P. M. told me that failures of uninsulated ground conductors, or other parts of the plant grounding system are not included in the Oconee PRA or the Keowee PRA. The only failure related to grounding that was included was in the Keowee PRA (June 1995), Section A.7.11.4 Human Interactions (page A.7-11), events GK1NGDCLHE and GK2NGDCLHE. These events represent a failure to close the neutral ground disconnects following maintenance or testing. This is not an aging failure and does not involve a failure of uninsulated ground conductors.
23. *Oconee Mechanical Component Aging Management Review for License Renewal*.
24. Oconee Environmental Qualification Master List.
25. Memo To File, 9/3/98, Oconee ATWS System Equipment Location, Information from John C. Carter, ONS ATWS System Engineer. I had a conversation with John Carter on Tuesday, June 16, 1998, regarding whether ATWS equipment was located in the Reactor Buildings. On June 18, he sent me an e-mail message that stated, "*Recall our Tuesday telephone conversation when you asked if Oconee's ATWS system had any of its components or cables inside the Reactor Building. At that time I was 99% sure no equipment belonging to ATWS was located inside the RB. Some additional research has confirmed that to be true. All inputs for ATWS are isolated taps from existing cables located outside containment. All outputs feed equipment located outside containment. No cables in the RB or penetrations are associated with the system, thus the system resides entirely outside of containment.*" In addition, on September 1, 1998, John and I investigated the reactor coolant pressure transmitters which originate the signals used by the ATWS System. These transmitters (RCP0244 and RCP0245) are located in the East Penetration rooms of each unit. Electrical elementary drawings show these transmitters and reference connection diagrams which indicate this location.
26. Appendix R to 10 CFR 50, Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979.
27. Oconee Station Specification for Operability Times Required for Safety Related Electrical Equipment Needed to Mitigate Design Basis Accidents (Oconee EQ Criteria Manual, Appendix 8.2), Section 1.0 - Introduction: "This document provides required operability times of equipment defined as follows: Safety related electrical equipment, systems and components required to mitigate, and bring the reactor to hot or cold shutdown, …."
28. NUREG/CR-6412, Aging and Loss-of-Coolant Accident (LOCA) Testing of Electrical Connections, January 1998.
29. Duke Power Specification for Wire Splice Insulating And Repair (600 Volts Or Less).
30. *Oconee Structures and Structural Component Aging Management Review for License Renewal*.
31. Memo To File, 7/30/98, SSF Cable Insulation Types, Information from Thamir J. All-Hussaini, NGO Cable Engineer. In an e-mail message on July 30, 1998 Thamir wrote, "*Oconee SSF cables were purchased per Catawba procurement specification. This specification requires the insulation material to be FREP, FRXLPE, Silicon Rubber or Tefzel depending on the cable application and/or the environment where the cable is to be installed.*" and "*As far as the SSF is concern, we used only FRXLPE or FREPR. The silicon rubber is used for the control ride drive, the pressurizer heater and some valves where the ambient temperature 60 degree C or higher. The tefzel used as a hookup wire where a small diameter wire is needed.*"
32. Memo To File, 9/8/99, Cables Used For Fire Detection Devices, information from Doug Brandes, Reene Gambrell and Thamir Al-Hussaini.
33. IEEE S-135/IPCEA P-46-426, 1984, *Power Cable Ampacities, Volume I — Copper Conductors*.
34. DC-3.12, Rev. 1, Cable Ampacity Design Criteria, Power Generation Electrical Discipline Design Manual.

35. National Electric Code, 1984.

36. DC-3.13, Revision 1, Oconee Nuclear Station Cable and Control Board Separation.

37. Memo To File, 6/17/98, Conductor Ampacities for Self-Heating Temperature Rise, Information from Steve Graham, NGO Electrical Systems & Equipment Engineering.

38. Memo To File, 9/9/98, Self-Heating Temperature Rise Calculations Including SSF Pressurizer Heater Cables along with the Spreadsheet Results. The self-heating temperature rise is calculated using the following formula:

    Temp Rise = (% Loading)^2 x 50°C *where* **% Loading = (RA/CR) x LF**

    where **50°C** is the difference between the assumed ambient of 40°C and the maximum conductor temperature rating of 90°C. **RA** is the load rated amps, **CR** is the cable rating, and **LF** is the load factor for the load. Therefore, **% Loading** is the maximum cable loading assumed to be constant throughout the life of the plant; that is, the plant never shuts down and the cable is continuously loaded at this value. **Temp Rise** is the temperature increase of the cable above a 40°C ambient when the cable is energized with the "% Loading." The calculations and explanatory notes were initially generated by William M. Denny, Ogden Environmental & Energy Services.

39. 10 CFR 50.49, Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants.

40. NUREG/CR-5643, BNL-NUREG-52323, "Insights Gained From Aging Research", Published March 1992, NRC Project Manager - Mr. Satish K. Aggarwal. The constructive comments provided by NRC reviewers from RES and NRR, particularly Mr. Jit Vora.

41. EPRI NP-1558, "A Review of Equipment Aging Theory and Technology," September 1980, Electric Power Research Institute.

42. F-C4020-2, March 1975, "Tests of Electrical Cables Under Simultaneous Exposure To Gamma Radiation, Steam And Chemical Spray While Electrically Energized," Report F-C4020-2, March 1975, Franklin Institute Research Laboratories.

43. Figure 15 ("Effect of Radiation Dose on Room-Temperature Tensile Strength & Elongation Retention (By ASTM D 638") "DuPont Tefzel Fluoropolymer Design Handbook," Publication E-04607, Copyright 1973, E.I. du Pont de Nemours & Co. Inc.

44. Westinghouse Electric Corporation Letter No. IPP-84-628 dated July 6, 1984.

45. EPRI NP-2129

46. NUREG/CR-6384, "Literature Review of Environmental Qualification of Safety-Related Electric Cables," Vol. 1, April 1996, Brookhaven National Laboratory, Prepared for U.S. Nuclear Regulatory Commission.

47. March 19, 1999, NRC Public Meeting Handouts, Presented by Brookhaven national Laboratory, Environmental Qualification Research on Low-Voltage Electric Cables, Sponsored by U.S. NRC, Office of Nuclear Regulatory Research

48. IPS-1079, "Design Qualification Test Report for Electrical Conductor Seal Assembly (ECSA) for CONAX Corporation (W/O 6-7E060)," Report No. IPS-1079, 9/6/83, CONAX Buffalo Corporation.

49. IPS-325, "Design Qualification Material Test Report for Materials Used in CONAX Electric Penetration Assemblies and Electric Conductor Seal Assemblies," Report No. IPS-325 Rev. D, 5/14/81, CONAX Corporation.

50. "Tefzel® - A 150°C Insulation," Bulletin E-00481 E.I. DuPont Co.

51. QR-5805, "Report on Qualification Tests for Firewall III Irradiation Cross-Linked Polyethylene Constructions for Class 1E Service in Nuclear Generating Stations," Report No. QR-5805, October 8, 1985, The Rockbestos Company.

52. Kerite Project No. 75-15, Kerite Engineering Memorandum No. 178B, dated 12/01/77.

53. SWBV2-0183, "Comparison of Okonite LOCA Simulation Service Profile and Stone & Webster, Beaver Valley - 2 Plant DBE Postulated Profile," Addendum 1 to "Nuclear Environmental Qualification Report for Okozel Insulated Cables," Report No. SWBV2-0183, The Okonite Company, approved by Stone & Webster Engineering Corporation, 1-9-86.

54. SD-157 A-75111, "Comparative Heat Resistance of Hypalon and Neoprene," undated, K. H. Whitlock, Elastomers Research Laboratory, Elastomers Chemicals Department, E. I. DuPont de Nemours & Co. (Inc.).

55. "Thermal Stability of Polymers," Volume 1, R. T. Conley, ed. New York: Marcel Dekker, Inc. Citation 973 of "A Review of Equipment Aging and Theory and Technology," EPRI NP-1558, September 1980, Electric Power Research Institute.

56. *Nylon and Polyethylene (PE) Thermal Life Endpoint Reduction*, 4-17-98, Information from William M. Denny, Ogden Environmental & Energy Services, calculates an endpoint lower than that shown in test reports to take advantage of extra margin since these non-EQ cables are not required to function during or after an accident or are not exposed to accident conditions.

57. E-44971, "DuPont Zytel® Nylon Resin Design Handbook," E-44971, undated, E. I. DuPont De Nemours & Co.

58. FYL-3, "Demonstration of 40 Year Life for Materials," Chart #1 Form FYL-3, The Okonite Company

59. Memo To File, 4/13/98, Oconee Unit Capacity Factor History, Information from Roger A. Williams, NGO Business Group. From initial operation through 1997, Oconee capacity factors are 71.32% (Unit 1), 73.26% (Unit 2), and 73.14% (Unit 3). The overall Oconee capacity factor for this period is 72.55%.

60. IR 99-12, NRC Inspection Report 50-269/99-12, 50-270/99-12 and 50-287/99-12, from Victor M. McCree, Deputy Director, Division of Reactor Safety, NRC, to Duke Energy Corporation, September 21, 1999.

61. SER OI 3.9.3-1, Letters in Response to SER (June 1999) Open Item 3.9.3-1: November 5, 1999 Letter from Duke to the NRC; December 17, 1999 Letter from Duke to the NRC, Attachment 1; January 4, 2000 Letter from NRC to Duke; January 12, 2000 Letter from Duke to the NRC; January 14, 2000 Letter from NRC to Duke

62. ONS LRA, July 6, 1998 Letter from Duke Energy Corporation to the NRC forwarding application for renewal of operating licenses for the Oconee Nuclear Station, Units 1, 2 and 3, Docket Nos. 50-269, 50-270 and 50-287.

63. NRC SER *(with open items)*, June 1999, Safety Evaluation Report related to the license renewal of Oconee Nuclear station, Units 1, 2 and 3, Docket Nos. 50-269, 50-270 and 50-287.

64. December 17, 1999 Letter from Duke to the NRC, included a response to four specific staff comments.

65. LR UFSAR Supplement, March 27, 2000 letter from W. R. McCollum Jr. (Duke) to Document Control Desk (NRC), License Renewal UFSAR Supplement, March 2000, Oconee Nuclear Station, Units 1, 2 and 3, Docket Nos. 50-269, 50-270 and 50-287.

66. SER OI 3.9.3-1 Revised Response, January 12, 2000 letter from M. S. Tuckman (Duke) to Document Control Desk (NRC), Response to NRC letter dated November 18, 1999, Revised Response to SER Open Item 3.9.3-1, Oconee Nuclear Station, Units 1, 2, and 3, Docket Nos. 50-269, -270, and -287.

67. NUREG-1723, ONS SER, Safety Evaluation Report Related to the License Renewal of Oconee Nuclear Station, Units 1, 2, and 3, Docket Nos. 50-269, 50-270, and 50-287.

68. Memo To File, 10/9/97, Transmission Tower Inspections, Interview with Paul Anderson, Duke Power Transmission Department.

69. Letter from Herman N. Johnson, Manager, Duke Engineering & Services Transmission Line Engineering, to R. L. Gill, Licensing Coordinator, Oconee License Renewal Project, November 14, 1997, regarding information for Oconee transmission lines, towers and insulators.

70. Memo To File, 4/29/97, Oconee High Voltage Insulators and Transmissions Lines, Information from James B. Sears, Duke Energy Electric Transmission. James Sears has worked with the Duke transmission system for over 15 years. The following information documents the discussion with James Sears.

Locke and Lapp brand insulators are the porcelain insulators Duke uses the most. Lapp currently has a plant in Sandersville, GA, that manufacturers post and cap & pin insulators.

There are different strength classes of insulators - Standard, High, and Extra High. Most 230kV applications use the high strength insulators. The insulators have a weight rating that relates to the strength; i.e., the number of pounds the insulator is designed to withstand. Most of the time the insulators are loaded to only half of their weight rating.

Testing is done by Doble & leakage current tests and visual inspections. Insulators can be cleaned with vinegar and a cleaning pad or shell blast.

Aging effects seen in the field for insulators include:
* chips and hairline cracks - usually caused by being hit by an object (rock, bullet) sometimes due to vandalism
* contamination - build-up of material on insulator, sometimes due to bird droppings; general build-up is normally not a problem; burn marks may be caused by lightning strike flashover on the insulator
* bolting - vibration wear on metal parts, corrosion; vibration wear is caused by lines swinging due to wind; might think it happens a lot but it doesn't. Only when there is a substantial wind do lines swing slightly and they don't continue long after the wind stops. This is due to the heavy weight of the conductors between towers and the small size of the cables.

71. Memo To File, 3/3/98, Telephone conversation with Charles E. Walker regarding the Oconee and Keowee electrical bus. A telephone conversation with Chuck Walker (Duke), Paul Colaianni (Duke), and Bill Denny (Ogden) was held on March 3, 1998, to discuss the bus at Oconee and Keowee. Information from a telephone conversation between Paul Colaianni and Chuck Walker on October 22, 1997, is also included in this memo. Chuck Walker is the Supervisor of a team that inspects and performs maintenance on electrical bus throughout the Duke Power system including Oconee and Keowee. Some of Chuck's team also participated in the conversation. Chuck has started working with this team in 1989 and he and his team have inspected all the bus at Oconee and Keowee bus since that time. Below is specific information relating to bus materials, inspections and findings from this conversation.

Oconee Nonsegregated-Phase Bus:
Boots (rubber insulating covers) are not installed on the bus in the bus runs. No boot or tape is used at "T" joints in bus runs. This has been true for as long as Chuck has been inspecting the bus. Boots and tape (130C with 88 tape as a top coat) are only used at bus connections in cubicles and switchgear. **Cork/Neoprene** is used and is repaired on a frequent basis. The cork/neoprene is prone to creep and must be repositioned. It is not replaced very frequently. Other than creep, no real problems have occurred with the gaskets. **No-Ox grease** is used on all electrical connections is cleaned off and replaced each time the bus is inspected. No degradation of the grease has ever been noticed during any inspection. **Porcelain insulators and bushings**: Some porcelain insulators and wall bushings have cracked and are replaced during inspections. The cracking is caused by mechanical stress exerted by the bus. Since 1989 approximately 6 wall bushings and 6 support insulators have been replaced. **Enclosure**: No corrosion or rust has been noticed on the bus enclosures inside the buildings or for the bus located outside in the Oconee Transformer Yard. No enclosures have had to be repaired. **Wall Baffles (baffle bushing assembly)**: Cement grout was originally used to seal the edge between the porcelain bushing and the bus. In many of the baffles the grout has cracked and has been supplemented or replaced with Dow Corning 3110 flexible epoxy. Brass flanges are used between the bushings and steel mounting plates. No rust or corrosion has been noticed on the mounting plates or hardware installed in the buildings or exposed to outside weather.

Keowee Isolated-Phase Bus:
No-Ox grease (Mobile 28) is used on all bolted electrical connections. **Grease** is cleaned off, the silver plating at the connection is checked and new grease is reapplied on each bolted connection during each inspection. **Rubber boots** are installed at connections only, not in the bus runs. **Grout** used in the wall baffles has not degraded and is in good condition. There have been no problems with cracked **porcelain insulators or bushings** in the bus. The **bus** is constructed of two pieces of channel aluminum facing each other to form a square. They are held together with spacers at about 8 foot intervals with laminated flex aluminum connections

about every 20 feet to serve as an expansion joint. The bus is held in place by an aluminum support. The bus is not welded or bolted to the support. The **enclosure** is welded together with inspection ports. **Ground straps** are laminated aluminum. The only problems that have occurred is that several lock washers on the bolted connections have had to be replaced.

72. Memo To File, 2/19/98, Keowee Hydroelectric Unit Run Times, Information from Charles M. Misenheimer, NGO Severe Accident Analysis. Information on Keowee generation times was obtained for the Keowee Probabilistic Risk Assessment (PRA). The Period Hours (total number of hours) for the 13 year data period is 113976 hours. Over the 13 year period, Keowee Unit 1 ran 6839.5 hours which is 6% of the Period Hours. Keowee Unit 2 ran 5944.5 hours which is 5.2% of the Period Hours.
    Keowee Isolated-Phase Bus & Segregated-Phase Bus Self-Heating
    There is a separate of isolated-phase bus and segregated-phase bus for each Keowee unit. Therefore, the maximum percentage of time the buses for either unit carries current is 6%.
    Keowee Transmission Line Self-Heating
    This transmission line connects both Keowee units to the 230kV Switchyard. No simultaneous run data on the Keowee units was available. Conservatively, the maximum percentage of time the Keowee Transmission Line is carrying current is the total the two individual units which is 12784 hours or 11.2%.

73. Memo To File, 9/3/98, Keowee Hydroelectric Unit Internal Power Loads, Information from Jeff Rowell, ONS Electrical Systems & Equipment Engineering. When the Keowee units are not generating power to the 230kV Switchyard, the internal power loads of one unit are fed from the 230kV Switchyard by back feeding through the Keowee main step-up transformer and the internal power loads of the other unit are fed from the underground 4160V feeder. Keowee internal power load information was obtained from plant computer system data points. For August 1998, the power demand as sampled every 6 hours had a maximum of 1.1 MW and minimum of 0.133 MW with an average of 0.684 MW.

74. QR-7802, "Report on Qualification Tests for Rockbestos Firewall SR Generic Nuclear Incident for Class 1E Service in Nuclear Generating Stations," Report No. QR-7802, 1/21/88, The Rockbestos Company.

75. Oconee Nuclear Station Specification for 7200 Volt and 4160 Volt Station Auxiliary Switchgear Nonsegregated-Phase Bus.

76. Oconee procedure for Inspection and Maintenance of ITE Type HK Metal-Clad Switchgear, Associated Bus and Disconnects.

77. Memo To File, 2/20/98, Calculated Self-heating Temperature Rise for Nonsegregated-Phase Bus, Information from Harold Walker, NGO Electrical Systems Engineering, Steve Graham, NGO Electrical Systems Engineering, W. M. Denny, Ogden Environmental and Energy Services. I had a conversation with the Nuclear General Office bus expert regarding bus heat rise and the determination was that it is not necessarily a difficult thing to calculate as long as you have accurate bus impedance values. Bus impedance values for each section of the nonsegregated-phase bus have not been calculated and are not available. To bridge the gap, a simplified approach that works for cables was used for the bus. This approach involves obtaining the bus rating and the actual bus load. Segregated-phase bus impedance and current values were obtained from the Oconee power system load flow studies. A load flow case was chosen that has the lowest generator voltage and, therefore, the highest currents. Voltage as low as in this case is not expected to occur very often and calculating self-heating of the nonsegregated-phase bus using these currents is conservative. Loading on the three Oconee units is essentially the same and the bus configurations between the units is very similar. Therefore, Unit 1 was chosen for load flow data and the results are applied to all three units. The rating of the bus sections was obtained from the purchase specification. I forwarded this information William M. Denny, Ogden Environmental and Energy Services, for incorporation into a spreadsheet to calculate the self-heating temperature rise using the same method used for cables. The results indicate a maximum self-heating temperature rise of approximately 35.4°C.

78. ANSI/IEEE C37.23-1987, "IEEE Guide for Metal-Enclosed Bus and Calculating Losses in Isolated-Phase Bus," The Institute of Electrical and Electronics Engineers, Inc.

79. Letter dated 3/20/98 from Herman N. Johnson, Duke Engineering & Services, Transmission Line Engineering, to R. Paul Colaianni, Oconee License Renewal Project, regarding transmission conductors in the 230kV Switchyard.

80. IEEE Transactions on Power Delivery, Vol. 7, No. 2, April 1992, “Aged ACSR Conductors, Part I - Testing Procedures for Conductors and Line Items”, by D. G. Harvard, G. Bellamy, P. G. Buchan, H. A. Ewing, D. J. Horrocks, S. G. Krishnasamy, J. Motlis, and K. S. Yoshiki-Gravelsins; and “Aged ACSR Conductors, Part II - Prediction of Remaining Life”, by D. G. Harvard, M. K. Bissada, C. G. Fajardo, D. J. Horrocks, J. R. Meale, J. Motlis, M. Tabatabai, and K. S. Yoshiki-Gravelsins; Ontario Hydro, Toronto, Canada; 0885-8977/91/©1992 IEEE; Contact IEEE, 445 Hoes Lane, Piscataway, NJ, USA 08855-1331, 732-981-0060 to obtain a copy of these papers. (Also attached to Reference 69 as Appendix B Items 11 and 12.)

81. Design Basis Specification for the Auxiliary Building HVAC System.

82. Design Basis Specification for the Control Room Ventilation System.

83. Memo To File, 5/24/00, Cables Installed in and Bulk Temperatures of the Essential Siphon Vacuum Building, Information from Henry Harling, Oconee Engineering and Gary Chronister, Oconee Modification Engineering. I had a telephone conversation on May 24, 2000 with Gary Chronister to get information on cable routing in the Essential Siphon Vacuum Building at Oconee. Gary informed me that the cables are installed and routed in the building at a low height; no more than four feet above the floor. Later that day I received information from Henry Harling in a telephone message regarding temperature information on the Essential Siphon Vacuum Building at Oconee. The calculation *Estimation of Equilibrium Temperatures for ESV Building due to Natural Draft* predicts a bulk temperature maximum of 125°F. This temperature would be with no power available and no fans running. To do this with a model Henry measured temperatures at the 8 foot level in the building. He said it might be possible to use a temperature of 110°F for the cables but he would not know for sure without doing a calculation. With the fans running, which is the normal configuration, the bulk temperature should not get above 110°F. The louvers are at the bottom of the building and the cooler are would be there.

84. Design Basis Specification for the Reactor Building Ventilation System.

85. Memo To File, 4/15/98, Oconee Reactor Building Temperatures - From Temperature Monitors, Information from Robert J. Smith, NGO Electrical Systems & Equipment. I talked to Bob Smith on April 8 and April 13, 1998, regarding Reactor Building temperatures. The following information came from graphs Bob showed me that were made from temperature monitor readings from Unit 2. As I am interested only in long term aging, I ignored momentary temperature spikes shown on the graphs and looked for the highest temperatures indicated on the graphs for the monitors in the applicable areas. I also only looked at monitors inside the shield wall.

    Floor Elevation 797’+6” (Bottom of Reactor Coolant Pumps): 116°F (46.7°C)

    This is the level around the bottom of the reactor coolant pumps. One Unit 2 Reactor Building temperature monitor on elevation 797+6 indicated a maximum temperature of about 116°F during the 1995 Summer. The others on that elevation inside the shield wall indicated a maximum temperature of less than 105°F.

    Elevation Around the Top of the Reactor Coolant Pumps: 126°F (52.2°C)

    The maximum temperature recorded by one the Unit 2 Reactor Building temperature monitor on an elevation that is above and in the vicinity of the reactor coolant pumps was about 126°F at the end of July 1995.

    Elevations High In The Steam Generator Cavities: 132°F (55.6°C)

    A bounding temperature at high elevations in the steam generator cavities is 132°F (55.6°C). This is a 98% confidence value meaning that if you went out and measured the temperature, it would be at or below 132°F 98% of the time. The average temperature is more like 120°F (48.9°C).

86. Design Basis Specification for the Standby Shutdown Facility HVAC System

87. Memo To File, 9/10/98, Turbine Building General Temperatures, Average temperatures from the temperature monitoring on Unit 2. Temperatures have been monitored in general areas of the Unit 2 Turbine Building since July 15, 1996. Data from this monitoring was compiled by Bill Denny, Ogden Environmental & Energy Services. Bill sent me the attached memo which gives a summary of these monitored temperatures. The results show that the average temperature in general Turbine Building areas is less than 105°F.

88. Memo To File, 1/19/98, Appendix R Warehouse Service Environments, Information from Harold L. Lefkowitz, ONS Civil Engineering. The warehouse where Appendix R cable is stored is heated, has no cooling, does have roof vents and has fire suppression (dry pipe system).

89. The *Oconee Nuclear Station Environmental Qualification Criteria Manual* has the detailed radiation information that is used for qualifying electrical equipment in the EQ (§50.49) program.

90. Memo To File, 8/20/98, Jacket Materials for In-Scope Medium Voltage Power Cables Potentially Exposed to Moisture. The cable numbers are identified on one-line drawings and the cable types, insulation materials and jacket material were obtained from the cable database.

Load	Cable No.	Cable Type	Insulation Material	Jacket Material
Keowee 13.8kV		1BA500DB15	EPR	PVC
Keowee 4160V	1ETC4	1BA250DB5	EPR	PVC
CCW-1A	1TC5	3XJ600G5	EPR	PVC
CCW-1B	1TD4	3XJ600G5	EPR	PVC
CCW-1C	1TE4	3XJ600G5	EPR	PVC
CCW-1D	1TC6	3XJ600G5	EPR	PVC
CCW-2A	2TC4	3XJ600G5	EPR	PVC
CCW-2B	2TD4	3XJ600G5	EPR	PVC
CCW-2C	2TE4	3XJ600G5	EPR	PVC
CCW-2D	2TC5	3XJ600G5	EPR	PVC
CCW-3A	3PTC4	3XJ600G5	EPR	PVC
CCW-3B	3PTC5	3XJ600G5	EPR	PVC
CCW-3C	3PTD4	3XJ600G5	EPR	PVC
CCW-3D	3PTE4	3XJ600G5	EPR	PVC
ASW SWGR	1EB1T-10	1Z4/0G5	EPR	PVC
HPSW-A	1B2T-10	1Z2G5	EPR	PVC
HPSW-B	1B1T-4	1Z2G5	EPR	PVC
SSF	1ETS1, 1ETS2	3XJ500G8	EPR	PVC
230kV & 525kV Switchyard Power	1TE11	3XJ2G5	EPR	PVC
	2TE11	3XJ2G5	EPR	PVC

91. IIR B-953, 1/17/80, Incident Investigation Report No. B-935, “B” HPSW Pump Declared Inoperable Due to a Problem with the Power Cable.

PART 2
OCONEE ELECTRICAL COMPONENT TIME-LIMITED AGING ANALYSES FOR LICENSE RENEWAL

1
ELECTRICAL COMPONENT TIME-LIMITED AGING ANALYSIS METHODOLOGY

This chapter discusses the methodology used to address the electrical component time-limited aging analyses (TLAAs) for license renewal.

The *Oconee Specification for Identification and Evaluation of Time-Limited Aging Analyses for License Renewal* [Reference 1] determined that the components in the Oconee Environmental Qualification (EQ) Program meet the TLAA criteria as stated in § 54.3 and also determined that the only electrical components that met the TLAA criteria are those in the EQ Program. This Oconee report has the basis for that determination and that basis is not further discussed in this document.

The aging analyses are the actual component or commodity qualification reports and any supporting calculations. It is these qualification reports and calculations that are the subject of this report.

1.1 Requirements for Addressing TLAAs

The requirements for addressing TLAAs are given in § 54.21(c)(1) and are quoted below:

Table 1-1
§ 54.21(c) — Requirement for Evaluation of a TLAA

§ 54.21(c)
An evaluation of time-limited aging analyses.
(1) A list of time-limited aging analyses, as defined in § 54.3, must be provided. The applicant shall demonstrate that –
(i) The analyses remain valid for the period of extended operation;
(ii) The analyses have been projected to the end of the period of extended operation; or
(iii) The effects of aging on the intended function(s) will be adequately managed for the period of extended operation.

Contained in the above quote is a reference to § 54.3 which gives a definition of a TLAA. This definition is quoted below:

Table 1-2
§ 54.3 — Definition of TLAA

§ 54.3 Definitions

Time-limited aging analyses, for the purposes of this part, are those licensee calculations and analyses that:

(1) Involve systems, structures, and components within the scope of license renewal, as delineated in § 54.4(a);

(2) Consider the effects of aging;

(3) Involve time-limited assumptions defined by the current operating term, for example, 40 years;

(4) Were determined to be relevant by the licensee in making a safety determination;

(5) Involve conclusions or provide the basis for conclusions related to the capability of the system, structure, and component to perform its intended functions, as delineated in § 54.4(b); and

(6) Are contained or incorporated by reference in the CLB.

Contained in the above quote is a reference to § 54.4 regarding components within the scope of license renewal. This section is quoted below:

Table 1-3
§ 54.4 — Scope

§ 54.4 Scope

(a) Plant Systems, Structures, and components within the scope of this part are –

(1) Safety-related systems, structures, and components which are those relied upon to remain functional during and following design-basis events (as defined as in 10 CFR 50.49 (b)(1)) to ensure the following functions --

(i) The integrity of the reactor coolant pressure boundary;

(ii) The capability to shutdown the reactor and maintain it in a safe shutdown condition; or

(iii) The capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to the 10 CFR Part 100 guidelines.

(2) All-safety-related systems, structures, and components whose failure could prevent satisfactory accomplishment of any of the functions identified in paragraphs (a)(1)(i), (ii), or (iii) of this section.

(3) All systems, structures, and components relied on in safety analyses or plant evaluations to perform a function that demonstrated compliance with the Commission's regulation for fire protection (10 CFR 50.48), environmental qualification (10 CFR 50.49), pressurized thermal shock (10 CFR 50.61), anticipated transients without scram (10 CFR 50.62), and station blackout (10 CFR 50.63).

(b) The intended functions that these systems, structures, and components must be shown to fulfill in § 54.21 are those functions that are the bases for including them within the scope of license renewal as specified in paragraphs (a)(1)-(3) of this section.

Table 1-1 quotes the three options given in § 54.21(c)(1) that are available for completing a TLAA evaluation. These three options are:

- § 54.21(c)(1)(i) - Demonstrate that the analyses remain valid for the period of extended operation
- § 54.21(c)(1)(ii) - Demonstrate that the analyses have been projected to the end of the period of extended operation; or
- § 54.21(c)(1)(iii) - Demonstrate that the effects of aging on the intended function(s) will be adequately managed for the period of extended operation.

The option chosen for a specific component TLAA is specifically stated in the chapter that discusses the component. How these options are implemented when used is discussed below.

1.1.1 Demonstrate That The Analyses Remain Valid For The Period Of Extended Operation

Option (i) is chosen if the existing qualification analysis already qualifies the component for the period of extended operation. No further work is required if this is the case and the existing qualification analysis is summarized.

1.1.2 Demonstrate That The Analyses Have Been Projected To The End Of The Period Of Extended Operation

Option (ii) is chosen if the existing qualification analysis does not qualify the component for the period of extended operation. In these cases, a new analysis is performed based on the original qualification data and new environmental data that is available. The new environmental data comes from a containment temperature monitoring program that has been set up in the Oconee Unit 2 containment. These temperature monitors have been recording actual containment operating temperatures in key areas around electrical components since late 1994. Temperature monitoring was also installed in both the Unit 1 containment and Unit 3 containment at the beginning of 1997. The new analysis performed for each component using this option is documented in a Quality Assurance Condition 1 calculation and the results are summarized in this report.

1.1.3 Demonstrate That The Effects Of Aging On The Intended Function(s) Will Be Adequately Managed For The Period Of Extended Operation

Option (iii) is chosen if the existing component qualification analysis will not be reviewed as part of the license renewal application. Using this option relies on the regulatory driven EQ Program [Reference 2] of which all electrical component TLAAs are under. The EQ Program is in place to ensure that:

- Each electrical component within the scope of the EQ Program has a qualified life based on the component materials of construction and service environment (or an assumed bounding, conservative service environment).
- Each electrical component in the EQ Program is replaced prior to the expiration of its qualified life.

Therefore, the EQ Program ensures that the effects of aging on the intended function will be adequately managed for the period of extended operation. The EQ Program does not evaluate aging effects, but only ensures that evaluations and test data are in place which address the aging effects and ensure an appropriate qualified life is defined.

To understand the EQ Program better in the context of license renewal, the table below describes the various program attributes. Definitions for the program elements are given in Acronyms & Definitions.

Table 1-4
EQ Program Description

Program Elements	Program Element Description
Purpose	To meet the requirements of 10 CFR 50.49, *Environmental qualification of electric equipment important to safety for nuclear power plants*
Scope	Electrical equipment within the scope of 10 CFR 50.49
Aging Effects	NA
Method	Establish a qualified life based on appropriate considerations such as component materials of construction, service environment, and testing.
Sample Size	NA
Industry Codes or Standard	IEEE Standard 323-1974, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations
New Program Details	NA
Frequency	NA
Acceptance Criteria	Electrical equipment is qualified per the requirements of 10 CFR 50.49
Corrective Action	As directed by the Duke Power Quality Assurance Program
New Program Initiation	NA
Administrative Controls	Nuclear Policy Manual/Nuclear Station Directive for EQ, EQ Criteria Manual (EQCM), EQ Master List (EQML) , Oconee response to IE Bulletin 79-01 B, EQ Maintenance Manual (EQMM), Maintenance Directive (MD) for EQ
Regulatory Basis	10 CFR 50.49, UFSAR Chapter 3.11

1.2 Environmental Stressors Evaluated

The components identified in this document are currently qualified for the appropriate thermal and radiation environments for long-term aging effects as well as to be able to function as required after such aging in an accident environment (e.g., elevated temperature, elevated pressure, elevated humidity, chemical spray, submergence). As the accident environment should not change from that in the original analyses, thermal and radiation aging are the only aspects of the qualification that will be reviewed for license renewal.

2
OCONEE EQ PROGRAM SUMMARY DESCRIPTION

This program description was generated following a meeting with the NRC staff on January 19, 1999 in response to the requests or additional information (RAIs) for Section 5.6 of Exhibit A of the Oconee license renewal application [Reference 3]. During the meeting the staff reviewed several qualification calculations or EQ components and the following descriptions satisfied the staff with regards to the Oconee EQ program meeting the TLAA review and demonstration requirements. This information was provided back to the staff in response to the RAIs [Reference 4, Attachment 3].

2.1 Introduction

The Nuclear Regulatory Commission (NRC) has established nuclear station environmental qualification (EQ) requirements in 10 CFR 50 Appendix A, Criterion 4, and in 10 CFR 50.49. 10 CFR 50.49 specifically requires that an EQ program be established to demonstrate that certain electrical equipment located in “harsh” plant environments (i.e., those areas of the plant that could be subject to the harsh environmental effects of a loss of coolant accident (LOCA), high energy line breaks (HELBs) and post-LOCA radiation) are qualified to perform their safety function in those harsh environments. The requirements of §50.49 apply to all new and replacement electrical equipment, within the scope of the §50.49, purchased after February 22, 1983. The scope of equipment covered by the Oconee EQ program is:

- Safety-related (as defined in §50.49) electrical equipment located in a postulated harsh environment that is required to mitigate the consequences of the accident causing the harsh environment, or whose subsequent failure can degrade safety systems or mislead the plant operator.
- Nonsafety-related electrical equipment located in a postulated harsh environment whose failure could prevent a safety function or mislead the plant operator. The impact to emergency operation procedures should be considered in the failure analysis.
- Post-accident monitoring equipment located in a postulated harsh environment designated as requiring qualification in the Regulatory Guide 1.97 section of Duke Power Company’s Response to Supplement 1 of NUREG-0737.

The Oconee EQ program is implemented in accordance with the regulatory and industry standards identified in the letter from J. F. Stolz (NRC) to H. B. Tucker (Duke) dated March 20, 1985, which transmitted the *Safety Evaluation Report on Environmental Qualification of Electrical Equipment Important to Safety* for Oconee Nuclear Station. Unless otherwise identified, these are the regulatory and industry standards referred to elsewhere in this EQ program summary description.

The Oconee EQ program is described in Section 3.11 of the Oconee UFSAR and is administratively controlled by a nuclear station directive which explicitly defines the responsibilities and requirements for implementing the Oconee EQ program to ensure compliance with §50.49.

The Oconee EQ program is currently implemented as described in this summary. Changes in the implementation of the Oconee EQ program as described in this summary are made whenever appropriate by changing the controlling nuclear station directive. Changes to the nuclear station directive for the EQ program are administratively controlled by a nuclear station directive, which gives instructions for administrative procedures, and by the Oconee quality assurance process to ensure continued compliance with §50.49.

The Oconee EQ program consists of activities which are integrated into the overall plant design and modification process, including initial design and modification (e.g., selection and application of equipment), documentation review and approval, maintenance, refurbishment, replacement, and procurement. The following is a summary description of these activities and how they are implemented.

2.2 Oconee EQ Program Responsibilities

Oconee EQ program responsibilities are assigned to several groups within Duke.

- **The nuclear general office** has the responsibility to provide overall administration of the EQ program, provide technical support for EQ related issues, control and administer the EQ maintenance manual, resolve generic EQ issues, and provide information to the other station sections and divisions to maintain qualification.
- **Station engineering** has the responsibility to provide information and technical support to the craft and other station sections and divisions for EQ related issues, ensure that all EQ mandated activities are addressed and scheduled, control and administer the EQ master list and the EQ criteria manual, ensure that the station modification process addresses EQ requirements such as the degree of documentation required, specify applicable environmental parameters in procurement documents, and review and approve environmental qualification test plans.
- **The station maintenance organization** has the responsibility to write and implement station procedures, and ensure that maintenance personnel are properly trained on the EQ program.
- **Other departments who maintain equipment at the station** are responsible for ensuring the qualification of EQ equipment is maintained as specified by the EQ maintenance manual.

2.3 EQ Process

The Oconee EQ program consists of activities which are integrated into the overall plant design and modification process. The following is a summary description of these activities and how they are implemented.

2.4 Original Qualification Basis

In establishing the original qualification basis for the equipment and in developing the EQ master list and EQ maintenance manual, all equipment within the scope of §50.49 was reviewed per the requirements of the quality assurance program. Each test report was reviewed , a test report summary was placed on file and each piece of equipment, by tag number, was reviewed to document that qualification of the equipment was adequate for its intended application.

The EQ process is controlled by the EQ master list and the EQ maintenance manual which are described next.

2.5 EQ Master List

The EQ master list provides an up-to-date, controlled listing of electrical equipment in the Oconee EQ program. All EQ master list information must be originated and revised according to the nuclear station directive, which controls the EQ program. The EQ master list provides the following equipment information:

- Station tag number of the equipment
- The manufacturer and model or series number for the equipment
- The building, floor elevation and specific location of the equipment
- If the equipment is located in a harsh or mild environment
- The applicable EQ maintenance manual section which addresses maintaining the qualification of the equipment
- The equipment installation date
- The qualified life of the equipment

2.6 EQ Maintenance Manual

The EQ maintenance manual defines the specific requirements for maintaining EQ equipment in its qualified configuration and ensures consistency in maintaining the qualification of all electrical equipment within the scope of §50.49. All EQ maintenance manual information must be originated and revised according to the nuclear station directive, which controls the EQ program. The EQ maintenance manual specifically addresses the following activities:

- EQ mandated maintenance required to maintain the equipment qualification
- The qualified life of the equipment, any component part to be replaced and the replacement interval (i.e., replace cover o-ring every 18 months)
- The electrical cable termination method
- If the equipment cable entrance must be sealed to prevent moisture intrusion
- Installation and mounting configurations required to maintain qualification

- The shelf life for the equipment or components parts along with storage requirements
- Procurement and reorder information specific to the equipment

Documentation such as maintenance manuals, test reports, calculations, and installation specifications from which the maintenance requirements originate, or which must be used to implement the maintenance requirements, is referenced under each of the maintenance activities. The requirements contained in the EQ maintenance manual section for specific equipment are incorporated into craft work procedures (maintenance, termination, sealing, installation), the work management system (scheduling and replacement), and procurement engineering procedures (shelf life and procurement).

2.7 Replacement of EQ Equipment

Prior to the expiration of the qualified life of a piece of EQ equipment, a notice is generated by the Oconee work management system to alert engineering that the equipment is scheduled for replacement in the near future. Several options are available as discussed in the following subsections.

2.7.1 Replace The Existing Component With An Identical Component

This option only requires the generation of a work order and an update to the EQ master list since all the required documentation and procedures already exist.

2.7.2 Replace The Equipment With Different Equipment Which Is Already Evaluated Under The EQ Program

When new or replacement EQ equipment is installed in the plant which is currently addressed in the EQ maintenance manual, the equipment is added to the EQ master list and a review is performed which:

- Confirms that the EQ maintenance manual addresses the specific manufacturer and model number of the equipment.
- Identifies the plant areas for which the component is qualified to be installed.
- Identifies the applicable EQ test report summary as listed in the EQ maintenance manual.
- Identifies additional documentation relevant to the application versus the tested configuration and test parameters.
- Identifies where the equipment is to be located and whether the location is in a postulated harsh environment area.
- Confirms that the new or replacement component is qualified for its application.

2.7.3 Replace The Equipment With Different Equipment Which Is Not Currently Evaluated Under The EQ Program

When replacing a piece of equipment with one not currently addressed in the EQ program, a QA Condition 1 calculation that verifies assumptions and conclusions is performed to document the qualification of the equipment. This QA Condition 1 calculation includes the following:

- **Equipment Data –** Includes data such as equipment tag numbers, manufacturer, QA condition, specifications, and applicable test report.
- **Functional Review –** Determines applicability of §50.49 to the equipment; i.e., installed in a postulated harsh environmental area, required to operate during an accident, etc.
- **Environmental Qualification Review -** Examines appropriate aspects such as test parameters versus installed location accident parameters, operability times, qualified life, equipment tested versus installed equipment, and test report anomalies.

The information identified above is evaluated and a determination made that the equipment is not qualified for the application or it certifies that the equipment is qualified for the application.

2.8 Reanalyze The Qualified Life Calculation

The reanalysis is performed for a specific application to extend the qualified life if excess conservatism exists in the original qualified life calculation. Conservatisms may exist in parameters such as the assumed ambient temperature of the equipment, an unrealistically low activation energy, or in the application of equipment (de-energized versus energized). The reanalysis is documented under a QA Condition 1 calculation, which has data to verify all assumptions and conclusions. Typically, the guidelines outlined in EPRI TR-104873, Methodologies And Processes To Optimize Environmental Qualification Replacement Intervals, are followed. Specific aspects of the way a reanalysis is performed are discussed below:

2.8.1 Analytical Methods

The Arrhenius methodology is the thermal model used to perform a reanalysis. It should be noted, per the NRC EQ Task Action Plan (TAP) (reference NUREG/CR-6384), that moisture has not been identified as a significant aging mechanism in regards to thermal aging. During normal operations, equipment is only subjected to ambient humidity levels (20-90%), which was also dismissed as an aging stressor per the NRC EQ TAP. EQ equipment is typically sealed and cable insulation is protected from the occasional inadvertent spray. Exposure to moisture due to leaks is investigated on a case by case basis. The analytical method used for radiation reanalysis is to identify the 40-year radiation dose from the EQ criteria manual for the area where the equipment is installed, multiply that value by the ratio of the evaluation period divided by 40 years (e.g., for license renewal 60 years/40 years = 1.5), and add the applicable accident radiation dose to obtain the total integrated dose for the equipment.

2.8.2 Data Collection & Reduction Methods

Reducing excess conservatisms in the equipment service temperatures used in existing analyses is the chief method used for reanalysis. Temperature data used in a reanalysis is obtained from actual temperature measurements in the area around the equipment being reanalyzed. Temperature measurements can be obtained in several ways, examples of which are through monitors used for Technical Specification compliance, other installed monitors, measurements made by plant operators during rounds, and temperature sensors on large motors (while the motor is not running). A representative number of temperature measurements are mathematically reduced to arrive at a temperature used in a reanalysis. These reduction methods are statistically based with the purpose of achieving a specific confidence level. For example, typically a 99.73% confidence mean temperature is calculated which indicates the temperature in the area is at or below this temperature 99.73% of the time. Temperatures may be used in several ways in a reanalysis such as (a) using the actual calculated temperature, or (b) using the calculated temperature to validate or show conservatism when using the a design temperature for a reanalysis.

2.8.3 Underlying Assumptions

Conservatisms in the EQ equipment qualification analyses have been sufficient to absorb environmental changes occurring due to plant modification and events and there have been no major plant modifications or events at Oconee of sufficient duration that have changed the temperature and radiation values that were used in the underlying assumptions in the EQ calculations. The process by which changes to the underlying assumptions will be made in the future is discussed in the section of this summary program description titled **Plant Environmental Changes**.

2.8.4 Acceptance Criteria & Corrective Actions

Adequate margin, as suggested in IEEE Standard 323-1974 and DOR Guidelines, are maintained in all reanalyses, or adequate justification for not maintaining margin is provided. If the reanalysis does not maintain adequate margin and less margin cannot be justified, the equipment qualification is not extended and the equipment is replaced as scheduled prior to the expiration of the existing qualification.

2.9 Refurbishment of EQ Equipment

When equipment needs refurbishment, Duke typically replaces the installed equipment with new equipment or previously refurbished equipment taken out of storage. The removed equipment is then refurbished and placed in storage. Qualified equipment is required to be refurbished before it can be placed back into storage if the equipment is to be used in EQ applications following storage. Refurbishment is performed in a manner that preserves its qualification. This is typically accomplished by replacing “soft” items such as gaskets, seals, and wires which have a limited life.

All EQ limited life, replacement parts are identified in the EQ maintenance manual for a particular equipment, manufacturer and model. Additionally, guidance for shelf life of refurbished equipment is contained in the introduction to the EQ maintenance manual.

2.10 On-going Qualification/Retesting

On-going qualification or retesting as described in IEEE Std. 323-1974, Section 6.6(1) or (2) is not currently considered a viable option at Oconee and there are no plans to implement such an option. If this option becomes viable in the future, on-going qualification or retesting would be incorporated into station directives administering the EQ program and the associated activities would be performed in accordance with accepted industry and regulatory standards.

2.11 Procurement of EQ Equipment

Procurement policy and criteria for QA Condition 1 equipment within the scope of §50.49 is controlled by the nuclear station directive for equipment procurement, the nuclear station directive for the EQ program, and the nuclear station directive for the quality standards manual.

Procurement of like-for-like replacement EQ equipment is controlled such that the equipment procured is as good as or better than the original equipment. The procurement process also assures applicable performance requirements and qualification criteria are met. Guidance for assuring qualification is found in the EQ maintenance manual section for a particular piece of equipment. The procurement section in the EQ maintenance manual addresses the manufacturer or vendor from which to purchase the equipment, the test reports to be referenced on the requisition and the specification numbers to which the equipment is to be purchased.

Specifications for procurement of new EQ equipment are reviewed by the nuclear general office or the Oconee EQ coordinator to ensure applicable performance requirements and qualification criteria are met. Test plans are reviewed and approved prior to testing to assure compliance with the specification. Upon receipt of a new test report, the responsible engineer will initiate an EQ test report and analysis summary, which establishes the qualification of the equipment. A copy of the summary is also inserted into the test report and is formally placed on file under a controlled documentation number. Updating the EQ master list and the EQ maintenance manual are handled similar to the replacement process addressed above.

2.12 Plant Environmental Changes

Plant environmental zones are identified in the Oconee EQ criteria manual. The EQ criteria manual identifies the harsh environmental areas of the plant for loss of coolant accidents (LOCAs), high energy line breaks (HELBs), and radiation. The EQ criteria manual is a Quality Assurance (QA) Condition 1 controlled document. Measurements of critical parameters (e.g., containment temperatures for Technical Specification requirements) are trended on an ongoing basis.

Changes in environmental parameters are reviewed by the nuclear general office EQ coordinator in conjunction with the EQ criteria manual responsible engineer to address affected EQ equipment on a generic basis. If the changes cannot be dispositioned on a generic basis, the station problem investigation process would be initiated to resolve the specific equipment concerns. Adverse environmental changes are addressed on an ongoing basis.

When a significant environmental change is identified, a review of the qualification of affected EQ equipment is performed and applicable changes are made to the equipment qualified life. In addition, when a reanalysis is performed for the purposes of extending the qualified life, the environmental parameters for the equipment are verified. When environmental data used in an equipment reanalysis is confirmed to be accurate, the EQ criteria manual, if appropriate, is revised to reflect the new operating conditions. Equipment reanalyses are performed under calculations whose assumptions and environmental data are reviewed periodically for continued validity.

3
COMPONENTS IN THE EQ PROGRAM

Components in the EQ Program are the only electrical components associated with a TLAA. Information about the EQ Program at Oconee is contained in a Nuclear Station Directive (NSD) [Reference 5] and information regarding specific components in the program can be found in the EQ Master List (EQML) [Reference 6], the EQ Maintenance Manual (EQMM) [Reference 7], and the Oconee response to IE Bulletin 79-01 B [Reference 8].

The components in the EQ Program that involve a TLAA per the § 54.3 definition are those electrical components with a qualified life of 40 years or more. This is criteria (3) in Table 1-2. Component analyses that determine a qualified life of less than 40 years do not meet this criteria, are not TLAAs, and are not reviewed.

3.1 Chapter Assignments

The component TLAAs to be reviewed for license renewal are determined by a review of the EQ Program reference materials mentioned above. These component TLAAs are grouped by component type with each component type assigned a separate chapter and specific components reviewed in separate subsections. The components types, electrical components and chapter numbers are listed in the table below.

Table 3-1
List of Electrical Components With a TLAA

Component Type	Electrical Component	Chapter/Section	
Accelerometers	TEC Monitor Accelerometers	4	4.1
Actuators	Limitorque Actuators	5	5.1
	Rotork Actuators		5.2
Cables & Wire	Anaconda EPR/Hypalon & EPR/Neoprene Cables	6	6.1
	BIW CSPE Cables		6.2
	Brand-Rex & Samuel Moore PVC Cables		6.3
	Brand-Rex Flame Retardant XLPE Cables		6.4
	ITT Suprenant & Raychem Cross-linked Polyalkene Hook-up Wire		6.5
	Kerite-HTK Cables		6.6
	Okonite EPR/Neoprene Cables		6.7
	Samuel Moore EPDM/Hypalon Cables		6.8
Connector & Sealing Assemblies	ScotchCast 9 And Swagelok Quick-Connect Assemblies	7	7.1
Heat Shrink Tubing	Raychem NCBK Nuclear Cable Breakout Splice Assemblies	8	8.1
	Raychem NPKV Nuclear Plant Stub Connection Kit		8.2
	Raychem WCSF-N In-line Splice Assemblies		8.3
	EGS Grayboots		8.4
	EGS Connectors		8.5
Motors	Joy/Reliance Motors	9	9.1
	Louis-Allis Motors		9.2
	Reliance Motors		9.3
	Westinghouse BS Pump Motors		9.4
	Westinghouse HPI Pump & LPI Pump Motors		9.5
Penetration Assemblies	Conax Electrical Penetration Assemblies	10	10.1
	D. G. O'Brien Electrical Penetration Assemblies		10.2
	Viking Electrical Penetration Assemblies		10.3
RTDs	Conax RTDs	11	11.1
	Rosemount RTDs		11.2
	Weed RTDs		11.3
Solenoid Valves	Valcor Solenoid Valves	12	12.1
Switches	Barton/Westinghouse Switches	13	13.1
Terminal Blocks	States & Stanwick Terminal Blocks	14	14.1
Transmitters	Gems Delaval Level Transmitters	15	15.1
	Barton Model 764 Transmitters		15.2
	Rosemount Transmitters		15.3

4
ACCELEROMETERS

There is one type of accelerometer associated with a TLAA. It is reviewed in the following section.

4.1 TEC Monitor Accelerometers

TEC monitor accelerometers are used as part of the PORV (pressure operated relief valve) Acoustical Monitoring System. Other parts of the system are in the EQ Program but the TEC monitor accelerometers are the only components that are qualified for 40 years.

Option (i) as discussed in Subsection 1.1.1 is chosen for TEC monitor accelerometers; i.e., demonstrate that the analyses remain valid for remain valid for the period of extended operation.

TEC monitor accelerometers are age insensitive and are qualified through the period of extended operation. An Oconee calculation [Reference 9] documents this analysis of qualified life. The details of this analysis are contained in the calculation.

As required by § 54.21(c)(1), the Oconee calculation demonstrates that the analyses of TEC monitor accelerometers used in EQ applications remain valid for the period of extended operation.

5 ACTUATORS

There are two types of actuators associated with a TLAA. These are reviewed separately in the following sections.

5.1 Limitorque Actuators

Limitorque Actuators are used in all areas of Oconee Nuclear Station.

Option (ii) as discussed in Subsection 1.1.2 is chosen for Limitorque Actuators; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. An analysis of the qualified life was completed using actual ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years.

An Oconee calculation [Reference 10] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

Limitorque Actuators are qualified for both inside containment and outside containment. Both of these applications are included in this analysis.

5.1.1 Thermal Analysis Summary

Inside containment Limitorque Actuators are qualified to the equivalent of 135 years at an average ambient temperature of 140°F (60°C).

The bounding average ambient temperature (including areas inside the steam generator cavities) is 135.67°F (57.59°C) which is below the 140°F (60°C) temperature for a 135-year life. Therefore, inside containment Limitorque Actuators are qualified through the period of extended operation.

Outside containment Limitorque Actuators are qualified to the equivalent of 60 years at an average ambient temperature of 137.96°F (58.87°C).

The bounding average outside containment ambient temperature is 122°F (50°C) which is below the 137.96°F (58.87°C) temperature for a 60-year life. Therefore, outside containment Limitorque Actuators are qualified through the period of extended operation.

5.1.2 Radiation Analysis Summary

Inside containment Limitorque Actuators are qualified to 2.04E8 rads.

Outside containment Limitorque Actuators are qualified to 2.0E8 rads.

The worst case inside containment 40-year radiation dose is 3.0E7 rads. For 60 years the dose equals 4.5E7 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.1E7 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 1.06E8 rads.

The worst case outside containment 40-year radiation dose is 1.0E6 rads. For 60 years the dose equals 1.5E6 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.0E6 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 7.0E6 rads.

Comparing the qualified dose (2.04E8 rads for inside containment, 2.0E8 rads for outside containment) to the TID through the extended period (1.06E8 rads inside containment, 7.0E6 rads outside containment) shows that the TID is well within the bounds of the qualification. Therefore, the Limitorque Actuators (inside and outside containment) are qualified through the period of extended operation.

5.1.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Limitorque Actuators used in EQ applications to the end of the period of extended operation.

5.2 Rotork Actuators

Option (iii) as discussed in Subsection 1.1.3 is chosen for Rotork Actuators; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

Rotork Actuators currently have a 40-year qualified life. There are no plans to extend the qualified life of Rotork Actuators and they are not analyzed for license renewal. The EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

6
CABLES

There are several types of cables associated with a TLAA. These are reviewed separately in the following sections.

6.1 Anaconda EPR/Hypalon & EPR/Neoprene Cables

Anaconda EPR/Hypalon and EPR/Neoprene cables are used extensively throughout Oconee Nuclear Station in motor operated valve (MOV) and solenoid valve applications.

Option (ii) as discussed in Subsection 1.1.2 is chosen for Anaconda EPR/Hypalon and EPR/Neoprene cables; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for Anaconda EPR/Hypalon and EPR/Neoprene cables was determined and an analysis of the qualified life was completed using actual temperature rise and ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of Anaconda EPR/Hypalon and EPR/Neoprene cables.

An Oconee calculation [Reference 11] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

6.1.1 Thermal Analysis Summary

Anaconda EPR/Hypalon and EPR/Neoprene cables are qualified for a 40-year life at 181.4°F (83°C).

The bounding EQ application of Anaconda EPR/Hypalon and EPR/Neoprene cables was found to be Valcor Model V526 solenoid valves. With a continuous 1.5 amps, the cables would experience a heat rise due to self-heating of 1.63°C.

The ambient temperature is conservatively assumed to be 122°F (50°C).

The maximum cable conductor temperature (ambient temperature plus self-heating) is 124.93°F (51.63°C). At 124.93°F (51.63°C), the qualified life of Anaconda EPR/Hypalon and EPR/Neoprene cables is in excess of 60 years [Figure 1 of Reference 11]. Therefore, the Anaconda EPR/Hypalon and EPR/Neoprene cables are qualified through the end of the period of extended operation.

6.1.2 Radiation Analysis Summary

Anaconda EPR/Hypalon and EPR/Neoprene cables are qualified to 2.0E8 rads.

The worst case containment 40-year radiation dose is 3.0E7 rads. For 60 years the dose equals 4.5E7 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.1E7 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 1.06E8 rads.

Comparing the qualified dose (2.0E8 rads) to the TID through the extended period (1.06E8 rads) shows that the TID is well within the bounds of the qualification. Therefore, the Anaconda EPR/Hypalon and EPR/Neoprene cables are qualified through the period of extended operation.

6.1.3 Conclusion

As required by § 54.21(c)(1), the calculation demonstrates that Anaconda EPR/Hypalon and EPR/Neoprene cables used in EQ applications to the end of the period of extended operation.

6.2 BIW CSPE Cables

BIW CSPE cables is used throughout Oconee Nuclear Station in instrumentation applications.

Option (ii) as discussed in Subsection 1.1.2 is chosen for BIW CSPE cables; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for BIW CSPE cables was determined and an analysis of the qualified life was completed using actual temperature rise and ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of BIW CSPE cables.

An Oconee calculation [Reference 12] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

6.2.1 Thermal Analysis Summary

BIW CSPE cables are qualified to 40 years at 131°F (55°C).

BIW CSPE cables are used for both transmitters and RTDs in EQ applications. For both of these applications the signal is in the milli-amp range which does not produce significant self-heating in the cable. Therefore, no self-heating was considered in the qualified life analysis.

The average ambient temperature (including areas inside the steam generator cavities) is conservatively assumed to be 120°F (48.89°C). At 120°F (48.89°C), the qualified life of BIW CSPE cables is in excess of 60 years [Figure 1 of Reference 12]. Therefore, BIW CSPE cables are qualified through the period of extended operation.

6.2.2 Radiation Analysis Summary

BIW CSPE cables are qualified to 1.14E8 rads.

The worst case containment 40-year radiation dose is 3.0E7 rads. For 60 years the dose equals 4.5E7 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.1E7 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 1.06E8 rads.

Comparing the qualified dose (1.14E8 rads) to the TID through the extended period (1.06E8 rads) shows that the TID is well within the bounds of the qualification. Therefore, the BIW CSPE cables are qualified through the period of extended operation.

6.2.3 Conclusion

As required by § 54.21(c)(1), the calculation has projected the analyses of BIW CSPE cables used in EQ applications to the end of the period of extended operation.

6.3 Brand-Rex & Samuel Moore PVC Cables

Brand-Rex and Samuel Moore PVC cables are used outside the Reactor Building at Oconee Nuclear Station in instrumentation and ASCO solenoid valve applications.

Option (ii) as discussed in Subsection 1.1.2, is chosen for Brand-Rex and Samuel Moore PVC cables; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for Brand-Rex and Samuel Moore PVC cables was determined and an analysis of the qualified life was completed using actual temperature rise and ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of Brand-Rex and Samuel Moore PVC cables.

An Oconee calculation [Reference 13] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

6.3.1 Thermal Analysis Summary

Brand-Rex and Samuel Moore PVC cables are qualified to 40 years at 140°F (60°C).

Brand-Rex and Samuel Moore PVC cables are used for both transmitters and pressure switches in EQ applications. For all of the applications the signal is in the milli-amp range which does not produce significant self-heating in the cable. Therefore, no self-heating was considered in the qualified life analysis.

The conservative average ambient temperature of the Penetration Rooms for all three units is 108°F (42.22°C). At 108°F (42.22°C), the qualified life of Brand-Rex and Samuel Moore PVC cables is in excess of 60 years [Figure 1 of Reference 13]. Therefore, Brand-Rex and Samuel Moore PVC cables are qualified through the period of extended operation.

6.3.2 Radiation Analysis Summary

Brand-Rex PVC cables are qualified to 8.26E7 rads.

Samuel Moore PVC cables are qualified to 5.0E6 rads.

The worst case Penetration Room 40-year radiation dose is 1.0E6 rads. For 60 years the dose equals 1.5E6 rads (1.5 times the 40-year dose). The worst case LOCA dose is 2.1E6 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 3.6E6 rads.

Comparing the qualified doses (8.26E7 rads, and 5.0E6 rads) to the TID through the extended period (3.6E6 rads) shows that the TID is well within the bounds of the qualification for both cable brands. Therefore, the Brand-Rex and Samuel Moore PVC cables are qualified through the period of extended operation.

6.3.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Brand-Rex and Samuel Moore PVC cables used in EQ applications to the end of the period of extended operation.

6.4 Brand-Rex Flame Retardant XLPE Cables

Brand-Rex flame retardant, cross-linked polyethylene (XLPE) insulated instrumentation cable is used at Oconee Nuclear Station in solenoid valve applications.

Option (ii) as discussed in Subsection 1.1.2 is chosen for Brand-Rex flame retardant XLPE cables; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for Brand-Rex flame retardant XLPE cables was determined and an analysis of the qualified life was completed using actual temperature rise and ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of Brand-Rex flame retardant XLPE cables.

An Oconee calculation [Reference 14] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

6.4.1 Thermal Analysis Summary

Brand-Rex flame retardant XLPE cables are qualified for 40 years at 161.6°F (72°C).

Brand-Rex flame retardant XLPE cables are used for ASCO Model 8316 and Valcor Model V70900-65 solenoid valves. The holding current for both of these applications is less then 0.2 amps. This low current does not produce significant self-heating in a #16 conductor. Therefore, no self-heating was considered in the qualified life analysis.

The conservative average ambient temperature of the Penetration Rooms for all three units is 108°F (42.22°C). At 108°F (42.22°C), the qualified life of Brand-Rex flame retardant XLPE cables is in excess of 60 years [Figure 1 of Reference 14]. Therefore, Brand-Rex flame retardant XLPE cables are qualified through the period of extended operation.

6.4.2 Radiation Analysis Summary

Brand-Rex flame retardant XLPE cables are qualified to 2.1E8 rads.

The worst case Penetration Room 40-year radiation dose is 1.0E6 rads. For 60 years the dose equals 1.5E6 rads (1.5 times the 40-year dose). The worst case LOCA dose is 2.1E6 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 3.6E6 rads.

Comparing the qualified dose (2.1E8 rads) to the TID through the extended period (3.6E6 rads) shows that the TID is well within the bounds of the cable qualification. Therefore, the Brand-Rex flame retardant XLPE cables are qualified through the period of extended operation.

6.4.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Brand-Rex flame retardant XLPE cables used in EQ applications to the end of the period of extended operation.

6.5 ITT Suprenant & Raychem Cross-linked Polyalkene Hook-up Wire

ITT Surprenant and Raychem cross-linked polyalkene (MIL W-81044) hook-up wire is used outside the Reactor Building at Oconee Nuclear Station in various applications.

Option (ii) as discussed in Subsection 1.1.2, is chosen for ITT Surprenant and Raychem cross-linked polyalkene hook-up wire; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for ITT Surprenant and Raychem cross-linked polyalkene hook-up wire was determined and an analysis of the qualified life was completed using actual temperature rise and ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of ITT Surprenant and Raychem cross-linked polyalkene hook-up wire.

An Oconee calculation [Reference 15] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

6.5.1 Thermal Analysis Summary

ITT Surprenant and Raychem cross-linked polyalkene hook-up wire is rated at a continuous operating temperature of 302°F (150°C).

ITT Surprenant and Raychem cross-linked polyalkene hook-up wire is used outside containment, primarily in terminal cabinets, typically as jumper wires on terminal blocks. For self-heating, the worst case application is on a normally energized Valcor Model V526 solenoid valve circuit which draws a continuous 1.5 amps current. With a continuous 1.5 amps, the wire would experience a 0.17°C heat rise due to self-heating. Since a 0.17°C heat rise is not significant, no self-heating was considered in the qualified life analysis.

The ambient temperature is conservatively assumed to be 122°F (50°C). At 122°F (50°C), the qualified life of both ITT Surprenant and Raychem cross-linked polyalkene hook-up wire is 60 years with significant margin. Therefore, ITT Surprenant and Raychem cross-linked polyalkene hook-up wire is qualified through the end of the period of extended operation.

6.5.2 Radiation Analysis Summary

ITT Surprenant and Raychem cross-linked polyalkene hook-up wire is qualified to 2.0E8 rads.

The worst case outside-containment 40-year radiation dose is 1.0E6 rads. For 60 years the dose equals 1.5E6 rads (1.5 times the 40-year dose). The worst case LOCA dose outside containment is 6.0E6 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 7.5E6 rads.

Comparing the qualified dose (2.0E8 rads) to the TID through the extended period (7.5E6 rads) shows that the TID is well within the bounds of the qualification. Therefore, ITT Surprenant and Raychem cross-linked polyalkene hook-up wire is qualified through the period of extended operation.

6.5.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Raychem and ITT Surprenant and Raychem cross-linked polyalkene hook-up wire used in EQ applications to the end of the period of extended operation.

6.6 Kerite-HTK Cables

Kerite-HTK cable is only used on the Reactor Building cooling unit (RBCU) fan motors at Oconee Nuclear Station.

Option (ii) as discussed in Subsection 1.1.2 is chosen for Kerite-HTK cables; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for Kerite-HTK cables was determined and an analysis of the qualified life was completed using actual temperature rise and ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of Kerite-HTK cables.

An Oconee calculation [Reference 16] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

6.6.1 Thermal Analysis Summary

Kerite-HTK cables are rated at a continuous operating temperature of 169.59°F (76.44°C) for 60 years.

The bounding EQ application of Kerite-HTK cables was found to be the RBCU fan motors which are assumed to operate at full load continuously. Maximum heat rise in the conductor due to self-heating was calculated to be 13.41°C.

The ambient temperature is conservatively assumed to be 122°F (50°C).

The resulting conductor temperature (ambient temperature plus self-heating) is 146.14°F (63.41°C). At 146.14°F (63.41°C), the qualified life of Kerite-HTK cables is in excess of 60 years [Figure 1 of Reference 16]. Therefore, Kerite-HTK cables are qualified through the period of extended operation.

6.6.2 Radiation Analysis Summary

Kerite-HTK cables are qualified to 2.0E8 rads.

The worst case containment 40-year radiation dose is 3.0E7 rads. For 60 years the dose equals 4.5E7 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.1E7 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 1.06E8 rads.

Comparing the qualified dose (2.0E8 rads) to the TID through the extended period (1.06E8 rads) shows that the TID is well within the bounds of the qualification. Therefore, Kerite-HTK cables are qualified through the period of extended operation.

6.6.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Kerite-HTK cables used in EQ applications to the end of the period of extended operation.

6.7 Okonite EPR/Neoprene Cables

Okonite EPR/Neoprene cables are used extensively throughout Oconee Nuclear Station in EQ and non-EQ applications.

Option (ii) as discussed in Subsection 1.1.2 is chosen for Okonite EPR/Neoprene cables; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for Okonite EPR/Neoprene cables was determined and an analysis of the qualified life was completed using actual temperature rise and ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of Okonite EPR/Neoprene cables.

An Oconee calculation [Reference 17] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

6.7.1 Thermal Analysis Summary

Okonite EPR/Neoprene cables are qualified for 40 years at 194°F (90°C).

The bounding EQ application of Okonite EPR/Neoprene cables was found to be the Reactor Building cooling units (RBCU). Heat rise in the conductor due to self-heating was calculated as a function of the actual current flowing in the conductor and the rated current of the conductor. The worst case conductor heat rise is 19.93°C.

The Okonite EPR/Neoprene cables on the RBCUs are located in the Reactor Building. The ambient temperature is conservatively assumed to be 122°F (50°C).

Based on the conductor heat rise of 19.93°C and ambient temperature of 122°F (50°C), the resulting conductor temperature (ambient temperature plus self-heating) is 157.87°F (69.93°C). At 157.87°F (69.93°C), the qualified life of Okonite EPR/Neoprene cables is well in excess of 60 years. Therefore, the Okonite EPR/Neoprene cables are qualified through the period of extended operation.

6.7.2 Radiation Analysis Summary

Okonite EPR/Neoprene cables are qualified to 2.0E8 rads.

The worst case containment 40-year radiation dose is 3.0E7 rads. For 60 years the dose equals 4.5E7 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.1E7 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 1.06E8 rads.

Comparing the qualified dose (2.0E8 rads) to the TID through the extended period (1.06E8 rads) shows that the TID is well within the bounds of the qualification. Therefore, Okonite EPR/Neoprene cables are qualified through the period of extended operation.

6.7.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Okonite EPR/Neoprene cables used in EQ applications to the end of the period of extended operation.

6.8 Samuel Moore EPDM/Hypalon Cables

Samuel Moore EPDM/Hypalon cables are used at Oconee Nuclear Station in instrumentation applications inside the Reactor Buildings and in the Penetration Rooms.

Option (ii) as discussed in Subsection 1.1.2 is chosen for Samuel Moore EPDM/Hypalon cables; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for Samuel Moore EPDM/Hypalon cables was determined and an analysis of the qualified life was completed using actual temperature rise and ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of Samuel Moore EPDM/Hypalon cables.

An Oconee calculation [Reference 18] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

6.8.1 Thermal Analysis Summary

The Samuel Moore EPDM/Hypalon cables are qualified for 40 years at 127°F (52.78°C).

Samuel Moore EPDM/Hypalon cables are used for level and pressure transmitter applications. For both of these applications the signal is in the milli-amp range which does not produce significant temperature rise in the cable. Therefore, no self-heating was considered in the qualified life analysis.

The conservative average ambient temperature of the Penetration Rooms for all three units is 108°F (42.22°C). At 108°F (42.22°C), the qualified life of Samuel Moore EPDM/Hypalon cables is in excess of 60 years [Figure 1 of Reference 18]. Therefore, Samuel Moore EPDM/Hypalon cables in the Penetration Rooms are qualified through the period of extended operation.

The level transmitters in the Reactor Buildings are all located in the basement where the average temperature is 90°F (32.22°C). The Reactor Buildings basement average temperature is less than the Penetration Rooms average temperature. Therefore, the EPDM/Hypalon cables in the Reactor Buildings are also qualified in excess of 60 years.

6.8.2 Radiation Analysis Summary

Samuel Moore EPDM/Hypalon cables are qualified to 2.0E8 rads.

The worst case Penetration Room 40-year radiation dose is 1.0E6 rads. For 60 years the dose equals 1.5E6 rads (1.5 times the 40-year dose). The worst case LOCA dose is 2.1E6 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 3.6E6 rads.

The worse case inside containment 40-year radiation dose is 3.0E7 rads. For 60 years the dose equals 4.5E7 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.1E7 rads. The TID (normal 60-year dose plus LOCA dose) is 1.06E8 rads.

Comparing the qualified dose (2.0E8 rads) to the TIDs through the extended period (3.6E6 rads and 1.06E8 rads) shows that the TIDs are well within the bounds of the cable qualification for both areas. Therefore, the Samuel Moore EPDM/Hypalon cables are qualified through the period of extended operation.

6.8.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Samuel Moore EPDM/Hypalon cables used in EQ applications to the end of the period of extended operation.

7 CONNECTOR AND SEALING ASSEMBLIES

There is one type of connector and sealing assembly associated with a TLAA. It is reviewed in the following section.

7.1 ScotchCast 9 And Swagelok Quick-Connect Assemblies

ScotchCast 9 and Swagelok quick-connect assemblies are used on motor-operated valves (MOVs), solenoid valves, limit switches, and transmitters.

Option (ii) as discussed in Subsection 1.1.2 is chosen for ScotchCast 9 and Swagelok quick-connect assemblies; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for ScotchCast 9 and Swagelok quick-connect assemblies was determined and an analysis of the qualified life was completed using ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of ScotchCast 9 and Swagelok quick-connect assemblies.

An Oconee calculation [Reference 19] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

7.1.1 Thermal Analysis Summary

ScotchCast 9 and Swagelok quick-connect assemblies are qualified for 40 years at 140°F (60°C).

ScotchCast 9 and Swagelok quick-connect assemblies are used for MOVs, solenoid valves, limit switches, and transmitters. These applications produce an insignificant self-heating temperature rise. Therefore, no self-heating was considered in the qualified life analysis.

The conservative yearly average ambient temperature of the steam generator cavities is for all three units is 129°F (53.89°C). At 129°F (53.89°C), the qualified life of ScotchCast 9 and Swagelok quick-connect assemblies is in excess of 60 years. Therefore, ScotchCast 9 and Swagelok quick-connect assemblies are qualified through the period of extended operation.

7.1.2 Radiation Analysis Summary

ScotchCast 9 and Swagelok quick-connect assemblies are qualified to 2.2E8 rads.

The worst case inside-containment 40-year radiation dose is 3.0E7 rads. For 60 years the dose equals 4.5E7 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.1E7 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 1.06E8 rads.

Comparing the qualified dose (2.2E8 rads) to the TID through the extended period (1.06E8 rads) shows that the TID is well within the bounds of the qualification. Therefore, ScotchCast 9 and Swagelok quick-connect assemblies are qualified through the period of extended operation.

7.1.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of ScotchCast 9 and Swagelok quick-connect assemblies used in EQ applications to the end of the period of extended operation.

8 HEAT SHRINK TUBING

There is one type of heat shrink tubing associated with a TLAA. It is reviewed in the following section.

8.1 Raychem NCBK Nuclear Cable Breakout Splice Assemblies

Raychem NCBK nuclear cable breakout splice assemblies are used extensively throughout Oconee Nuclear Station in all types of applications.

Option (ii) as discussed in Subsection 1.1.2 is chosen for Raychem NCBK nuclear cable breakout splice assemblies; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for Raychem NCBK nuclear cable breakout splice assemblies was determined and an analysis of the qualified life was completed using actual temperature rise and ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of Raychem NCBK nuclear cable breakout splice assemblies.

An Oconee calculation [Reference 20] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

8.1.1 Thermal Analysis Summary

Raychem NCBK nuclear cable breakout splice assemblies without an overall sleeve are qualified for 40 years at 167°F (75°C).

Raychem NCBK nuclear cable breakout splice assemblies are used on field cables servicing MOVs, solenoid valves, and transmitters. As such, the temperature rise due to self-heating of the conductors is negligible. To be conservative, a 10°C temperature rise due to self-heating was assumed.

A conservative ambient temperature was assumed to be 122°F (50°C).

The resulting splice assembly temperature (ambient temperature plus self-heating) is 140°F (60°C). This 140°F (60°C) envelopes ambient temperature plus heat rise of the splice assembly installations in all plant areas. At 140°F (60°C), the qualified life of Raychem NCBK nuclear cable breakout splice assemblies is in excess of 60 years [Figure 1 of Reference 20]. Therefore, Raychem NCBK nuclear cable breakout splice assemblies are qualified through the period of extended operation.

8.1.2 Radiation Analysis Summary

Raychem NCBK nuclear cable breakout splice assemblies are qualified to 2.0E8 rads.

The worse case inside containment 40-year radiation dose is 3.0E7 rads. For 60 years the dose equals 4.5E7 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.1E7 rads. The TID (normal 60-year dose plus LOCA dose) is 1.06E8 rads.

Comparing the qualified dose (2.0E8 rads) to the TID through the extended period (1.06E8 rads) shows that the TID is well within the bounds of the qualification. Therefore, Raychem NCBK nuclear cable breakout splice assemblies are qualified through the period of extended operation.

8.1.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Raychem NCBK nuclear cable breakout splice assemblies used in EQ applications to the end of the period of extended operation.

8.2 Raychem NPKV Nuclear Plant Stub Connection Kit

Raychem NPKV nuclear plant stub connection kits are used extensively throughout Oconee Nuclear Station in all types of applications.

Option (ii) as discussed in Subsection 1.1.2 is chosen for Raychem NPKV nuclear plant stub connection kits; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for Raychem NPKV nuclear plant stub connection kits was determined and an analysis of the qualified life was completed using actual temperature rise and ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of Raychem NPKV nuclear plant stub connection kits.

An Oconee calculation [Reference 21] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

8.2.1 Thermal Analysis Summary

Raychem NPKV nuclear plant stub connection kits are qualified for 42.8 years at 194°F (90°C).

Raychem NPKV nuclear plant stub connection kits are used on field cables servicing MOVs, solenoid valves, and transmitters. As such, the temperature rise due to self-heating of the conductors is negligible. To be conservative, a 10°C temperature rise due to self-heating was assumed.

A conservative ambient temperature for Raychem NPKV nuclear plant stub connection kits was assumed to be 122°F (50°C).

The resulting stub connection temperature (ambient temperature plus self-heating) is 140°F (60°C). This 140°F (60°C) envelopes ambient temperature plus heat rise of stub connection installations in all plant areas. At 140°F (60°C), the qualified life of Raychem NPKV nuclear plant stub connection kits is in excess of 60 years [Figure 1 of Reference 21]. Therefore, Raychem NPKV nuclear plant stub connection kits are qualified through the period of extended operation.

8.2.2 Radiation Analysis Summary

Raychem NPKV nuclear plant stub connection kits are qualified to 2.0E8 rads.

The worse case inside containment 40-year radiation dose is 3.0E7 rads. For 60 years the dose equals 4.5E7 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.1E7 rads. The TID (normal 60-year dose plus LOCA dose) is 1.06E8 rads.

Comparing the qualified dose (2.0E8 rads) to the TID through the extended period (1.06E8 rads) shows that the TID is well within the bounds of the qualification. Therefore, Raychem NPKV nuclear plant stub connection kits are qualified through the period of extended operation.

8.2.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Raychem NPKV nuclear plant stub connection kits used in EQ applications to the end of the period of extended operation.

8.3 Raychem WCSF-N In-line Splice Assemblies

Raychem WCSF-N in-line splice assemblies are used extensively throughout Oconee Nuclear Station in all types of applications.

Option (ii) as discussed in Subsection 1.1.2 is chosen for Raychem WCSF-N in-line splice assemblies; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for Raychem WCSF-N in-line splice assemblies was determined and an analysis of the qualified life was completed using actual temperature rise and ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of Raychem WCSF-N in-line splice assemblies.

An Oconee calculation [Reference 22] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

8.3.1 Thermal Analysis Summary

Raychem WCSF-N in-line splice assemblies are qualified for 44.2 years at 194°F (90°C).

Raychem WCSF-N in-line splice assemblies are used on many types of components. The worst case (bounding) application would be Reactor Building cooling unit (RBCU) fan motors. Heat rise in the conductor due to self-heating was calculated be a maximum of 19.93°C.

The RBCU fans motors are located in the Reactor Building and a conservative ambient temperature was assumed to be 122°F (50°C).

The resulting conductor temperature (ambient temperature plus self-heating) is 157.87°F (69.93°C). At 157.87°F (69.93°C), Raychem WCSF-N in-line splice assemblies have a projected life well in excess of 60 years [Figure 1 of Reference 22]. Therefore, the Raychem WCSF-N in-line splice assemblies are qualified through the period of extended operation.

8.3.2 Radiation Analysis Summary

Raychem WCSF-N in-line splice assemblies are qualified to 2.20E8 rads.

The worse case inside containment 40-year radiation dose is 3.0E7 rads. For 60 years the dose equals 4.5E7 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.1E7 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 1.06E8 rads.

Comparing the qualified dose (2.20E8 rads) to the TID through the extended period (1.06E8 rads) shows that the TID is well within the bounds of the qualification. Therefore, Raychem WCSF-N in-line splice assemblies are qualified through the period of extended operation.

8.3.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Raychem WCSF-N in-line splice assemblies used in EQ applications to the end of the period of extended operation.

8.4 EGS Grayboots

Option (iii) as discussed in Subsection 1.1.3 is chosen for EGS Grayboots; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

EGS Grayboots were initially installed in 1994 and have a 40-year qualified life. There are no plans to extend the qualified life of EGS Grayboots and they are not analyzed for license renewal. The Oconee EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

8.5 EGS Connectors

Option (iii) as discussed in Subsection 1.1.3 is chosen for EGS Connectors; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

EGS Connectors were initially installed in April 1993 and have a 40-year qualified life. There are no plans to extend the qualified life of EGS Connectors and they are not analyzed for license renewal. The Oconee EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

9
MOTORS

There are several types of cables associated with a TLAA. These are reviewed separately in the following sections.

9.1 Joy/Reliance Motors

Option (iii) as discussed in Subsection 1.1.3 is chosen for Joy/Reliance motors; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

Joy/Reliance motors currently have a 40-year qualified life. There are no plans to extend the qualified life of Joy/Reliance motors and they are not analyzed for license renewal. The EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

9.2 Louis-Allis Motors

Option (iii) as discussed in Subsection 1.1.3 is chosen for Louis-Allis motors; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

Louis-Allis Motors currently have a 40-year qualified life. There are no plans to extend the qualified life of Louis-Allis motors and they are not analyzed for license renewal. The EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

9.3 Reliance Motors

Option (iii) as discussed in Subsection 1.1.3 is chosen for Reliance motors; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

Reliance motors were initially installed in 1994 and have a 40-year qualified life [Reference 23, page 2]. There are no plans to extend the qualified life of Reliance motors and they are not analyzed for license renewal. The EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

9.4 Westinghouse BS Pump Motors

Option (iii) as discussed in Subsection 1.1.3 is chosen for Westinghouse building spray (BS) pump motors; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

Westinghouse BS pump motors have a 40-year qualified life but are in the process of being replaced [Reference 23, page 2]. There are no plans to extend the qualified life of Westinghouse BS pump motors and they are not analyzed for license renewal. The EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

9.5 Westinghouse HPI Pump & LPI Pump Motors

Westinghouse pump motors are used in several EQ applications at Oconee Nuclear Station. This section summarizes the qualified life analysis of high pressure injection (HPI) pump and the low pressure injection (LPI) pump motors.

Option (ii) as discussed in Subsection 1.1.2 is chosen for Westinghouse HPI and LPI pump motors; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The motor applications and operating parameters were determined and an analysis of the qualified life was performed using actual ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years.

An Oconee calculation [Reference 23] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

9.5.1 Thermal Analysis Summary

Westinghouse HPI and LPI pump motors are qualified for 40 years at 221°F (105°C).

The stator temperature of the Westinghouse HPI and LPI pump motors is monitored. The stator temperature is an indication of the combination of ambient temperature and the heat rise generated by the motor as it is running. To demonstrate conservatism, the peak stator temperatures for the Westinghouse HPI and LPI pump motors was used in the qualified life analysis.

The peak stator temperature of a Westinghouse HPI pump motor was 176.31°F (80.17°C). At an operating temperature of 176.31°F (80.17°C), the qualification of the Westinghouse HPI pump motors is in excess of 60 years [Figure 1 of Reference 23].

The peak stator temperature of a Westinghouse LPI pump motor was 202.66°F (94.81°C). At an operating temperature of 202.66°F (94.81°C), the qualification of the Westinghouse LPI pump motors is in excess of 60 years [Figure 1 of Reference 23].

Therefore, Westinghouse HPI and LPI pump motors are qualified through the period of extended operation.

9.5.2 Radiation Analysis Summary

Westinghouse HPI and LPI pump motors are qualified to 2.0E8 rads.

The worse case 40-year radiation dose for the Westinghouse HPI and LPI pump motors is 1.0E5 rads. For 60 years the dose equals 1.5E5 rads (1.5 times the 40-year dose). The worst case LOCA dose is 3.8E6 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 3.95E6 rads.

Comparing the qualified dose (2.0E8 rads) to the TID through the extended period (3.95E6 rads) shows that the TID is well within the bounds of the qualification. Therefore, Westinghouse HPI and LPI pump motors are qualified through the period of extended operation.

9.5.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Westinghouse HPI and LPI pump motors to the end of the period of extended operation.

10 PENETRATION ASSEMBLIES

There are several types of penetration assemblies associated with a TLAA. These are reviewed separately in the following sections.

10.1 Conax Electrical Penetration Assemblies

Conax electrical penetration assemblies are used in the Reactor Buildings at Oconee Nuclear Station.

Option (ii) as discussed in Subsection 1.1.2 is chosen for Conax electrical penetration assemblies; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for Conax electrical penetration assemblies was determined and an analysis of the qualified life was completed using actual ambient condition parameters, including radiation, to demonstrate a qualified life through a period of extended operation. This worst case application is used to bound all other applications of Conax electrical penetration assemblies.

An Oconee calculation [Reference 24] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

10.1.1 Thermal Analysis Summary

The ambient temperature is conservatively assumed to be 124.32°F (51,29°C). At 124.32°F (51,29°C), the qualified life of Conax electrical penetration assemblies is 56.8 years. The first Conax electrical penetration was installed in April 1986 so the 56 year qualified life will extend beyond April 2042. Therefore, Conax electrical penetration assemblies are qualified through the end of the period of extended operation.

10.1.2 Radiation Analysis Summary

Conax electrical penetration assemblies are qualified to 1.71E8 rads.

The worst case Reactor Building 40-year radiation dose is 3.0E7 rads. For 60 years the dose equals 4.5E7 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.1E7 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 1.06E8 rads.

Comparing the qualified dose (1.71E8 rads) to the TID through the extended period (1.06E8 rads) shows that the TID is well within the bounds of the qualification. Therefore, Conax electrical penetration assemblies are qualified through the period of extended operation.

10.1.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Conax electrical penetration assemblies to the end of the period of extended operation.

10.2 D. G. O'Brien Electrical Penetration Assemblies

D. G. O'Brien electrical penetration assemblies are used in the containment structures at Oconee Nuclear Station.

Option (ii) as discussed in Subsection 1.1.2 is chosen for D. G. O'Brien electrical penetration assemblies; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. An analysis of the qualified life of D. G. O'Brien electrical penetration assemblies was completed using actual ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years.

An Oconee calculation [Reference 25] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

10.2.1 Thermal Analysis Summary

The maximum self-heating temperature rise for a fully loaded penetration is 49°F.

The D. G. O'Brien electrical penetration assemblies are located in the Reactor Buildings. The ambient temperature at their locations is conservatively assumed to be 125°F (51.67°C).

Based on the self-heating temperature rise of 49°F and ambient temperature of 125°F (51.76°C), the resulting service temperature (ambient temperature plus self-heating) is 174°F (78.89°C). Based on original testing values and a service temperature of 174°F (78.89°C), the qualified life of D. G. O'Brien electrical penetration assemblies is well in excess of 60 years. Therefore, the D. G. O'Brien electrical penetration assemblies are qualified through the period of extended operation.

10.2.2 Radiation Analysis Summary

D. G. O'Brien electrical penetration assemblies are qualified to 1.03E8 rads.

The worst case containment 40-year radiation dose is 3.0E7 rads. For 60 years the dose equals 4.5E7 rads (1.5 times the 40-year dose). The worst case LOCA dose is 6.1E7 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 1.06E8 rads. Similar D. G. O'Brien electrical penetration assemblies used at McGuire and Catawba Nuclear Station were qualified to 2.0E8 rads.

Comparing the qualified dose (2.0E8 rads) to the TID through the extended period (1.06E8 rads) shows that the TID is well within the bounds of the qualification. Therefore, D. G. O'Brien electrical penetration assemblies are qualified through the period of extended operation.

10.2.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of D. G. O'Brien electrical penetration assemblies to the end of the period of extended operation.

10.3 Viking Electrical Penetration Assemblies

Viking electrical penetration assemblies are used extensively on all three Oconee units.

Option (i) as discussed in Subsection 1.1.1 is chosen for Viking electrical penetration assemblies; i.e., demonstrate that the analyses remain valid for the period of extended operation.

The qualification for Viking electrical penetration assemblies is contained in the Oconee vendor documentation file [Reference 26]. An analysis of qualified life (temperature and radiation) is performed in this vendor documentation to demonstrate a qualified life in excess of 60 years. This qualification analysis bounds all applications of Viking electrical penetration assemblies.

10.3.1 Thermal Analysis Summary

The Viking electrical penetration assembly vendor qualification demonstrates a qualified life of 62 years at 120°F (48.89°C) ambient which includes self-heating temperature rise. The actual yearly average ambient temperature for the penetration assemblies at the highest installed elevation in the Reactor Buildings is 102°F (38.89°C). The penetration assembly current rating is significantly derated from that used for vendor qualification and the 18°F difference envelopes the actual self-heating temperature rise. Therefore, the Viking electrical penetrations are qualified through the period of extended operation.

10.3.2 Radiation Analysis Summary

The vendor qualification demonstrates that Viking electrical penetration assemblies are qualified to 1.2E8 rads.

The bounding Reactor Building 60-year total integrated dose (normal dose plus LOCA dose) is 1.06E8 rads.

Comparing the qualified dose (1.2E8 rads) to the TID through the extended period (1.06E8 rads) shows that the TID is well within the bounds of the qualification. Therefore, Viking electrical penetration assemblies are qualified through the period of extended operation.

10.3.3 Conclusion

As required by § 54.21(c)(1), the qualification data for Viking electrical penetration assemblies contained in the Oconee vendor documentation file demonstrates that the analyses of Viking electrical penetration assemblies remain valid for the period of extended operation.

11 RTDs

There are several types of RTDs associated with a TLAA. These are reviewed separately in the following sections.

11.1 Conax RTDs

Option (iii) as discussed in Subsection 1.1.3 is chosen for Conax RTDs; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

Conax RTDs were initially installed in September 1991 and have a 40-year qualified life. There are no plans to extend the qualified life of Conax RTDs and they are not analyzed for license renewal. The EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

11.2 Rosemount RTDs

Option (i) as discussed in Subsection 1.1.1 is chosen for Rosemount RTDs; i.e., demonstrate that the analyses remain valid for the period of extended operation.

All materials in Rosemount RTDs are inorganic with the exception of the o-ring supplied with the manufacturer’s head. Oconee does not use the supplied head or the o-rings. With no organic materials, Rosemount RTDs are age insensitive and are qualified through the period of extended operation. The Rosemount vendor documentation [Reference 27] documents this information on materials and the analysis of qualified life. The details of this analysis are contained in Rosemount vendor documentation.

As required by § 54.21(c)(1), Rosemount vendor documentation demonstrates that the analyses of Rosemount RTDs used in EQ applications remain valid for the period of extended operation.

11.3 Weed RTDs

Option (iii) as discussed in Subsection 1.1.3 is chosen for Weed RTDs; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

Weed RTDs were initially installed in September 1991 and have a 40-year qualified life. There are no plans to extend the qualified life of Weed RTDs and they are not analyzed for license renewal. The EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

12
SOLENOID VALVES

There is one type of solenoid valve associated with a TLAA. It is reviewed in the following section.

12.1 Valcor Solenoid Valves

Option (iii) as discussed in Subsection 1.1.3 is chosen for Valcor solenoid valves; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

Valcor solenoid valves were initially installed after 1993 and have a qualified 40-year life. There are no plans to extend the qualified life of Valcor solenoid valves and they are not analyzed for license renewal. The EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

13
SWITCHES

There is one type of switch associated with a TLAA. It is reviewed in the following section.

13.1 Barton/Westinghouse Switches

Option (iii) as discussed in Subsection 1.1.3 is chosen for Barton/Westinghouse switches; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

Barton/Westinghouse switches were initially installed in 1986 and have a 40-year qualified life [documented in an Oconee calculation]. There are no plans to extend the qualified life of Barton/Westinghouse switches and they are not analyzed for license renewal. The EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

14
TERMINAL BLOCKS

There is one type of terminal block associated with a TLAA. It is reviewed in the following section.

14.1 States & Stanwick Terminal Blocks

States and Stanwick terminal blocks are used in solenoid valve circuits and are located in the Penetration Rooms.

Option (ii) as discussed in Subsection 1.1.2 is chosen for States and Stanwick terminal blocks; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for States and Stanwick terminal blocks was determined and an analysis of the qualified life was completed using ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of States and Stanwick terminal blocks.

An Oconee calculation [Reference 28] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

14.1.1 Thermal Analysis Summary

States and Stanwick terminal blocks are qualified for 40 years at 221°F (105°C).

States and Stanwick terminal blocks are used for solenoid valve circuits and are not subject to self-heating temperature rise due to low current. Therefore, no self-heating was considered in the qualified life analysis.

The conservative average ambient temperature of the Penetration Rooms for all three units is 108°F (42.22°C). At 108°F (42.22°C), the qualified life of States and Stanwick terminal blocks is in excess of 60 years [Reference 28, Figure 1]. Therefore, States and Stanwick terminal blocks are qualified through the period of extended operation.

14.1.2 Radiation Analysis Summary

States and Stanwick terminal blocks are qualified to 3.0E7 rads.

The worst case Penetration Room 40-year radiation dose is 1.0E6 rads. For 60 years the dose equals 1.5E6 rads (1.5 times the 40-year dose). The worst case LOCA dose is 2.9E5 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 1.79E6 rads.

Comparing the qualified dose (3.0E7 rads) to the TID through the extended period (1.79E6 rads) shows that the TID is well within the bounds of the cable qualification. Therefore, the States and Stanwick terminal blocks are qualified through the period of extended operation.

14.1.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of States and Stanwick terminal blocks used in EQ applications to the end of the period of extended operation.

15 TRANSMITTERS

There are several types of transmitters associated with a TLAA. These are reviewed separately in the following sections.

15.1 Gems Delaval Level Transmitters

Option (iii) as discussed in Subsection 1.1.3 is chosen for Gems Delaval level transmitters; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

Gems Delaval level transmitters currently have a 40-year qualified life. There are no plans to extend the qualified life of Gems Delaval level transmitters and they are not analyzed for license renewal. The EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

15.2 Barton Model 764 Transmitters

Barton Model 764 transmitters are used as Reactor Building pressure transmitters and are located in the Penetration Rooms.

Option (ii) as discussed in Subsection 1.1.2 is chosen for Barton Model 764 transmitters; i.e., demonstrate that the analyses have been projected to the end of the period of extended operation. The worst case (bounding) EQ application for Barton Model 764 transmitters was determined and an analysis of the qualified life was completed using ambient condition parameters, including radiation, to demonstrate a qualified life in excess of 60 years. This worst case application is used to bound all other applications of Barton model 764 transmitters.

An Oconee calculation [Reference 29] documents this analysis of qualified life. The details of this analysis are contained in the calculation. All information in this summary is copied from the calculation.

15.2.1 Thermal Analysis Summary

Barton Model 764 transmitters are qualified for 40 years at 122°F (50°C).

Barton Model 764 transmitters operate on a 4-20 milli-amp signal. Therefore, no self-heating is considered in the qualified life analysis.

The average ambient temperature of the Penetration Rooms for all three units is 108°F (42.22°C). At 108°F (42.22°C), the qualified life of Barton model 764 transmitters is in excess of 60 years. Therefore, Barton Model 764 transmitters are qualified through the period of extended operation.

15.2.2 Radiation Analysis Summary

Barton Model 764 transmitters are qualified to 2.0E8 rads.

The worst case Penetration Room 40-year radiation dose is 1.0E6 rads. For 60 years the dose equals 1.5E6 rads (1.5 times the 40-year dose). The worst case LOCA dose is 2.9E5 rads. The total integrated dose (TID, normal 60-year dose plus LOCA dose) is 1.79E6 rads.

Comparing the qualified dose (2.0E8 rads) to the TID through the extended period (1.79E6 rads) shows that the TID is well within the bounds of the cable qualification. Therefore, the Barton Model 764 transmitters are qualified through the period of extended operation.

15.2.3 Conclusion

As required by § 54.21(c)(1), the Oconee calculation has projected the analyses of Barton Model 764 transmitters used in EQ applications to the end of the period of extended operation.

15.3 Rosemount Transmitters

Option (iii) as discussed in Subsection 1.1.3 is chosen for Rosemount transmitters; i.e., demonstrate that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

Rosemount transmitters currently have a 40-year qualified life. There are no plans to extend the qualified life of Rosemount transmitters and they are not analyzed for license renewal. The EQ Program will ensure that the effects of aging on the intended functions will be adequately managed for the period of extended operation.

16
SUMMARY AND CONCLUSIONS

One of the three § 54.21(c)(1) demonstration methods was chosen for each electrical component TLAA. A summary of the method chosen for each electrical component TLAA is presented in the table below along with a cross-reference to the section and page number detailing the evaluation. This review found that the effects of aging on the intended function of all electrical components associated with a TLAA will be adequately managed for the period of extended operation.

TLAA Demonstration Option Distribution

The TLAA demonstration option distribution is a follows:

- Option (i) - 3 of the 34 (9%)
- Option (ii) - 18 of the 34 (53%)
- Option (iii) - 13 of the 34 (38%)

The Use of Demonstration Option (iii)

TLAA demonstration option (iii) and its use have been the focus of much attention by the NRC. The use of option (iii) for Oconee TLAAs fall into two categories:

1. Indicated with a * in the following table, 6 (18% of the 34) analyses are for original plant components that have 40-year life. There are no current plans to extend their qualified lives. This means they will probably be replaced sometime before their qualification expires. Oconee did not commit to replace these components during the initial license renewal application to leave the options open in the future.

2. Indicated with a ** in the following table, 7 (20% of the 34) analyses are for components that are replacements for components removed from service in the years 1986 through 1994. The replacements all have 40-year qualified lives so the qualified lives of these components expire in the years 2026 through 2034. The Oconee extended operating licenses will expire in the years 2031 (Unit 1) through 2034 (Unit 3). The earliest of the component qualifications expires 5 to 8 years before the end of the extended period of operation. As these expirations are close to the end of the extended period of operation, it is not worth any expense of resources to perform an evaluation of these components.

Table 16-1
Summary of Electrical TLAA Demonstration Methods

Demonstration Option	Electrical Component	Report Section With Details
(i)	TEC Monitor Accelerometers	Section 4.1
(ii)	Limitorque Actuators	Section 5.1
(iii) *	Rotork Actuators	Section 5.2
(ii)	Anaconda EPR/Hypalon & EPR/Neoprene Cables	Section 6.1
(ii)	BIW CSPE Cables	Section 6.2
(ii)	Brand-Rex & Samuel Moore PVC Cables	Section 6.3
(ii)	Brand-Rex Flame Retardant XLPE Cables	Section 6.4
(ii)	ITT Suprenant & Raychem Cross-linked Polyalkene Hook-up Wire	Section 6.5
(ii)	Kerite-HTK Cables	Section 6.6
(ii)	Okonite EPR/Neoprene Cables	Section 6.7
(ii)	Samuel Moore EPDM/Hypalon Cables	Section 6.8
(ii)	ScotchCast 9 And Swagelok Quick-Connect Assemblies	Section 7.1
(ii)	Raychem NCBK Nuclear Cable Breakout Splice Assemblies	Section 8.1
(ii)	Raychem NPKV Nuclear Plant Stub Connection Kit	Section 8.2
(ii)	Raychem WCSF-N In-line Splice Assemblies	Section 8.3
(iii) **	EGS Grayboots	Section 8.4
(iii) **	EGS Connectors	Section 8.5
(iii) *	Joy/Reliance Motors	Section 9.1
(iii) *	Louis-Allis Motors	Section 9.2
(iii) **	Reliance Motors	Section 9.3
(iii) *	Westinghouse BS Pump Motors	Section 9.4
(ii)	Westinghouse HPI Pump & LPI Pump Motors	Section 9.5
(ii)	Conax Electrical Penetration Assemblies	Section 10.1
(ii)	D. G. O'Brien Electrical Penetration Assemblies	Section 10.2
(i)	Viking Electrical Penetration Assemblies	Section 10.3
(iii) **	Conax RTDs	Section 11.1
(i)	Rosemount RTDs	Section 11.2
(iii) **	Weed RTDs	Section 11.3
(iii) **	Valcor Solenoid Valves	Section 12.1
(iii) **	Barton/Westinghouse Switches	Section 13.1
(ii)	States & Stanwick Terminal Blocks	Section 14.1
(iii) *	Gems Delaval Level Transmitters	Section 15.1
(ii)	Barton Model 764 Transmitters	Section 15.2
(iii) *	Rosemount Transmitters	Section 15.3

A
ACRONYMS AND DEFINITIONS

Acceptance Criteria (re: AMP): Measurable threshold values or identifiable criteria that can be used (1) to determine acceptability of the current physical configuration and (2) to trigger appropriate actions before there is a loss component function.

Administrative Controls (re: AMP): Identification or description of the plant procedure or other administratively controlled process under which the program will be implemented.

Aging Effects (re: AMP): A description of the potential aging effect to be managed by the program.

AMP: aging management program

AMR: aging management review

CFR: Code of Federal Regulations

CLB: current licensing basis

Corrective Action (re: AMP): Actions to be taken when an acceptance criteria is not met

EQ: environmental qualification

EQML: EQ Master List

EQMM: EQ Maintenance Manual

Frequency (re: AMP): The established frequency of the program actions which are adequate to detect the potential aging effects before a loss of component function would occurs.

HPI: high pressure injection

Industry Codes or Standards (re: AMP): Identification of NRC-accepted industry codes (e.g., IEEE) or standards (e.g., ASTM) that the program is to be performed in accordance with.

LOCA: loss of coolant accident

LPI: low pressure injection

LRA: license renewal application

Method (re: AMP): The type of action or technique used to manage the aging effects (e.g., visual inspection).

MOV: motor operated valve

NEI: Nuclear Energy Institute

New Program Details (re: AMP): A description of actions to be taken, methods to be followed and other program particulars that help clearly define the committed actions.

New Program Initiation (re: AMP): A description of the first time when the actions of a new program will take place.

NRC: Nuclear Regulatory Commission

NSD: Nuclear Station Directive

PORV: pressure operated relief valve

Purpose (re: AMP): A clear statement of the objective of the program.

RBCU: Reactor Building cooling unit

Regulatory Basis (re: AMP): Any existing Oconee regulatory basis for the program actions.

Sample Size (re: AMP): A description of the number of components or component parts to be inspected in relation to the total population.

Scope (re: AMP): A description of the components or component parts included in the program.

self-heating: generation of heat during operation of electrical devices sufficient to raise the device temperature above ambient temperatures; synonym: ohmic heating

TID: total integrated dose; normal radiation dose for the life of the component plus the LOCA or accident radiation dose

TLAA: time limited aging analysis, as defined in § 54.3 (see full text in Table 1-2)

B
REFERENCES

1. Oconee Specification for Identification and Evaluation of Time-Limited Aging Analyses for License Renewal.
2. 10 CFR 50.49, Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants.
3. November 25, 1998, NRC letter (from S. Hoffman) forwarding an RAI regarding Section 1.5.3, 2.6, 3.2, 3.6 and 5.6 of the Oconee license renewal application.
4. February 8, 1999, Letter from Duke energy corp. (signed by W. McCollum) to the NRC forwarding responses to NRC RAIs regarding the application for renewal of licenses for Oconee Nuclear Station.
5. Nuclear System Directive for Environmental Qualification
6. Equipment Qualification Master List
7. EQ Maintenance Manual
8. Oconee Response to IE Bulletin 79-01 B
9. Oconee Qualified Life Analysis for TEC Monitor Accelerometers
10. Oconee Qualified Life Analysis for Limitorque Motor Operated Valves
11. Oconee Qualified Life Analysis for Anaconda EPR/Hypalon and EPR/Neoprene Cable
12. Oconee Qualified Life Analysis for BIW Chlorosulfonated Polyethylene (CSPE) Cable
13. Oconee Qualified Life Analysis for Samuel Moore and Brand-Rex PVC Cable
14. Oconee Qualified Life Analysis for Brand-Rex Flame Retardant, Cross-linked Polyethylene Instrumentation Cable
15. Oconee Qualified Life Analysis for Raychem Corporation and ITT Surprenant MIL W-81044 Hook-up Wire
16. Oconee Qualified Life Analysis for Kerite HTK Insulated Cables
17. Oconee Qualified Life Analysis for Okonite EPR/Neoprene Cable
18. Oconee Qualified Life Analysis for Samuel Moore EPDM/Hypalon Cables
19. Oconee Qualified Life Analysis for ScotchCast 9 and Swagelok Quick-Connect Viton O-ring
20. Oconee Qualified Life Analysis for Raychem NCBK Nuclear Cable Breakout Splice Assemblies
21. Oconee Qualified Life Analysis for Raychem NPKV Nuclear Plant Stub Connection Kit
22. Oconee Qualified Life Analysis for Raychem WCSF-N In-line Splice Assemblies
23. Oconee Qualified Life Analysis for the Westinghouse Pump Motors
24. Oconee Qualified Life Analysis for Conax Electrical Penetrations
25. Oconee Qualified Life Analysis for D. G. O'Brien Electrical Penetrations

26. Manufacturer's Environmental Qualification Documentation Package for Electrical Penetration Assemblies - Viking Industries Inc. (Types A, B, C1, C2, D, E, E1, F1, F2, H1, H2, & H3, J, and K)

27. Manufacturer's Environmental Qualification Documentation Package for Rosemount RTDs

28. Oconee Qualified Life Analysis for States and Stanwick Terminal Blocks

29. Oconee Qualified Life Analysis for Barton Model 764 Transmitters

Target:
Nuclear Power

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