



Process for Infrastructure Aging Management and Life Extension of Nonreactor Nuclear Facilities

An American National Standard

ANSI/ANS-3.14-2021

Published by the
American Nuclear Society
555 N. Kensington Ave
La Grange Park, IL 60526



Documents
Document Sharing Hub

**American National Standard
Process for Infrastructure Aging
Management and Life Extension
of Nonreactor Nuclear Facilities**

Secretariat
American Nuclear Society

Prepared by the
**American Nuclear Society
Standards Committee
Working Group ANS-3.14**

Published by the
**American Nuclear Society
555 North Kensington Avenue
La Grange Park, Illinois 60526 USA**

Approved August 5, 2021
by the
American National Standards Institute, Inc.

American National Standard

Designation of this document as an American National Standard attests that the principles of openness and due process have been followed in the approval procedure and that a consensus of those directly and materially affected by the standard has been achieved.

This standard was developed under the procedures of the Standards Committee of the American Nuclear Society; these procedures are accredited by the American National Standards Institute, Inc., as meeting the criteria for American National Standards. The consensus committee that approved the standard was balanced to ensure that competent, concerned, and varied interests have had an opportunity to participate.

An American National Standard is intended to aid industry, consumers, governmental agencies, and general interest groups. Its use is entirely voluntary. The existence of an American National Standard, in and of itself, does not preclude anyone from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard.

By publication of this standard, the American Nuclear Society does not insure anyone utilizing the standard against liability allegedly arising from or after its use. The content of this standard reflects acceptable practice at the time of its approval and publication. Changes, if any, occurring through developments in the state of the art, may be considered at the time that the standard is subjected to periodic review. It may be reaffirmed, revised, or withdrawn at any time in accordance with established procedures. Users of this standard are cautioned to determine the validity of copies in their possession and to establish that they are of the latest issue.

The American Nuclear Society accepts no responsibility for interpretations of this standard made by any individual or by any ad hoc group of individuals. Inquiries about requirements, recommendations, and/or permissive statements (i.e., “shall,” “should,” and “may,” respectively) should be sent to the Society headquarters, ATTN: Standards or to standards@ans.org. Action will be taken to provide appropriate response in accordance with established procedures that ensure consensus.

Comments on this standard are encouraged and should be sent to Society headquarters.

Published by

American Nuclear Society
555 North Kensington Avenue
La Grange Park, Illinois 60526 USA



This document is copyright protected.

Copyright © 2021 by American Nuclear Society. All rights reserved.

Reproduction prohibited under copyright convention unless written permission is granted by the American Nuclear Society.

Printed in the United States of America

Inquiry Requests

The American Nuclear Society (ANS) Standards Committee will provide responses to inquiries about requirements, recommendations, and/or permissive statements (i.e., “shall,” “should,” and “may,” respectively) in American National Standards that are developed and approved by ANS. Responses to inquiries will be provided according to the Policy Manual for the ANS Standards Committee. Nonrelevant inquiries or those concerning unrelated subjects will be returned with appropriate explanation. ANS does not develop case interpretations of requirements in a standard that are applicable to a specific design, operation, facility, or other unique situation only and therefore is not intended for generic application.

Responses to inquiries on standards are published in ANS’s magazine, *Nuclear News*, and are available publicly at www.ans.org or by contacting standards@ans.org.

Inquiry Format

Inquiry requests shall include the following:

- (1) the name, company name if applicable, mailing address, and telephone number of the inquirer;
- (2) reference to the applicable standard edition, section, paragraph, figure, and/or table;
- (3) the purpose(s) of the inquiry;
- (4) the inquiry stated in a clear, concise manner;
- (5) a proposed reply, if the inquirer is in a position to offer one.

Inquiries should be addressed to

American Nuclear Society
ATTN: Standards
555 N. Kensington Avenue
La Grange Park, IL 60526

or standards@ans.org

Foreword

(This foreword does not contain any requirements of American National Standard “Process for Infrastructure Aging Management and Life Extension of Nonreactor Nuclear Facilities,” ANSI/ANS-3.14-2021, but is included for informational purposes.)

A significant number of nonreactor nuclear facilities (NRNFs) are reaching or have achieved their originally anticipated period of operation but are slated for continued operations for a number of additional years. As facilities age, safety and reliability margins provided by the design tend to decrease, and operations and maintenance costs and facility outages usually increase, unless age-related degradation of structures, systems, and components (SSCs) is appropriately managed by engineering and operations and maintenance personnel. The aging of facility SSCs important to safety needs to be effectively managed to ensure that the required safety functions are available throughout the life of the facility. In addition, those SSCs important to mission reliability also need to be properly managed for age-related degradation for reliable and economic facility operation.

While these aging facilities have maintenance programs to support ongoing operations, they face several aging challenges that could impact sustained safe operations: (1) systems that are degrading, (2) unavailability of replacement parts for critical SSCs, and (3) degrading supporting infrastructure. To support continued safe operations of aging facilities, this standard provides a risk-informed methodology for establishing requirements and methods for the selection of critical SSCs. This standard also provides an approach for conducting in-depth studies and inspections beyond routine maintenance programs needed for extending the life of selected SSCs through appropriate Aging Management Programs.

The objective of this standard is to provide an approach to evaluate the site and facility infrastructure, processes, and physical conditions and provide examples of how that information can be used to develop the essential elements required to establish an enhanced aging management and life extension process for NRNFs.

This standard incorporates the concept of risk-informed insights as part of selection of equipment to which the standard is applied. Performance-based decisions are also applied in the determination of condition monitoring techniques in the assurance of safe and reliable equipment operation. The working group has determined that the incorporation of more defined risk-informed and/or performance-based requirements in this standard may be worthwhile and intends to consider this in a future revision.

This standard might reference documents and other standards that have been superseded or withdrawn at the time the standard is applied. A statement has been included in the references section that provides guidance on the use of references.

This standard was prepared by the ANS-3.14 Working Group of the American Nuclear Society, which had the following membership at the time of its approval of this standard:

T. M. Anselmi (Cochair), *Idaho National Laboratory*
C. W. McMullin (Cochair), *Individual*

B. Burns, *U.S. Department of Energy*
J. Crociata, *Consolidated Nuclear Services*
M. Kotzalas, *U.S. Department of Energy*
H. W. Massie, Jr., *Massie Consulting, LLC*
M. Mudlock, *Simpson Gumpertz & Heger, Inc.*
J. O'Brien, *U.S. Department of Energy*
C. B. Sanford, *Simpson Gumpertz & Heger, Inc.*

The Nonreactor Nuclear Facilities Consensus Committee had the following membership at the time of its approval of this standard:

C. R. Martin (Chair), *Longenecker and Associates*
A. De La Paz (Vice Chair), *U.S. Department of Energy*

T. M. Anselmi, *Idaho National Laboratory*
L. J. Berg, *U.S. Department of Energy*
M. K. Gupta, *Amentum Technical Services*
D. Harrison, *U.S. Nuclear Regulatory Commission*
H. M. Hashemian, *AMS Corporation*
J. E. Hicks, *Individual*
R. V. Kazban, *Defense Nuclear Facilities Safety Board*
H. W. Massie, Jr., *Massie Consulting, LLC*
C. A. Mazzola, *TRIAD National Security (LANL)*
M. Modarres, *University of Maryland*
J. O'Brien, *U.S. Department of Energy*
P. Rogerson, *Savannah River Nuclear Solutions*

Contents

Section	Page
1	Introduction, scope, and application..... 1
1.1	Introduction 1
1.2	Scope 1
1.3	Application 1
2	Acronyms and definitions..... 2
2.1	Acronyms 2
2.2	Shall, should, and may 2
2.3	Definitions 2
3	Aging Management Program overview 3
4	Screening of facility SSCs..... 4
4.1	Identification and selection of facility SSCs 5
4.2	Initial review of current AMPs..... 8
5	Review of aging mechanisms..... 11
5.1	Conditions requiring immediate attention 11
5.2	Process for identification of degradation mechanisms 11
6	Management of aging mechanisms 12
6.1	Development of AMPs for components 12
6.2	Obsolescence..... 13
6.3	Prioritization of aging management activities 14
6.4	Aging management for structures and structural components..... 14
6.5	Structural evaluation of aging SSCs..... 15
6.6	Aging management and facility life extension 15
7	References 15

Appendices

Appendix A	Actions to Address Unknown Conditions..... 16
Appendix B	Risk Prioritization of Aging Management / Life Extension Activities..... 18
Appendix C	Worksheet for the Conduct of an Aging Management Review 29
Appendix D	Development of an Extended Life Program for an Aging Nuclear Process Facility in the U.S. Department of Energy 34
Appendix E	Aging Management and Evaluation of Aging Structures and Structural Components..... 41

Tables

Table 1	Examples of facility programs related to an AMP..... 8
Table 2	Key elements for an AMP..... 13

Figures

Figure 1	AMLE facility system screening 6
Figure 2	AMLE facility component and structure selection 10

Process for Infrastructure Aging Management and Life Extension of Nonreactor Nuclear Facilities

1 Introduction, scope, and application

1.1 Introduction

This standard¹⁾ provides an approach for aging management and life extension (AMLE) of nonreactor nuclear facilities (NRNFs).

The outcome of the application of this standard is the establishment of a program that provides for the timely detection and mitigation of age-related degradation to ensure that *required integrity and functional capability of the facility structures, systems, and components (SSCs)* are maintained.

1.2 Scope

This standard provides criteria and guidance to systematically evaluate SSCs for remaining lifetime and determine the need for additional analysis and inspection to address aging management in support of extending the life of NRNFs.

This standard applies to NRNFs²⁾ including facilities such as nuclear material processing and storage facilities as well as fuel fabrication and enrichment facilities or conversion/deconversion facilities.

1.3 Application

The term “aging management” is often interpreted to apply only to passive functions of a component or subsystem composed of multiple components providing the same function (e.g., pressure boundary integrity); however, the approach to aging management applies to any SSC. The SSCs within a nuclear facility have varying levels of importance, and a formal Aging Management Program (AMP) should be applied to at least those SSCs that support the safe operation of the facility and/or those SSCs where failure results in having to secure facility operation until the failed condition is corrected.

Although there may be several approaches to performing an aging management review (AMR), this standard presents an approach that utilizes aging mechanism and management information developed for the U.S. commercial nuclear power industry. This information is documented in U.S. Nuclear Regulatory

¹⁾ The current standard, ANSI/ANS-3.14-2021, is hereinafter referred to as “this standard.”

²⁾ Although this standard was developed with a focus on NRNFs, this standard can apply to multiple process facilities in many industries with equipment designed of similar materials and operating in similar environments, including nuclear facilities with nuclear reactors.

Commission (NRC) NUREG-2191, Volumes 1 and 2, “Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report” [1].^{3), 4)}

2 Acronyms and definitions

2.1 Acronyms

AMLE:	aging management and life extension
AMP:	Aging Management Program
AMR:	aging management review
DSA:	Documented Safety Analysis
GALL-SLR Report:	NUREG-2191, “Generic Aging Lessons Learned for Subsequent License Renewal Report”
NRC:	U.S. Nuclear Regulatory Commission
NRNF:	nonreactor nuclear facility
NUREG:	NRC technical publication
SAR:	Safety Analysis Report
SC:	safety class
SS:	safety significant
SSC(s):	structure(s), system(s), and component(s)

2.2 Shall, should, and may

shall, should, and may: The word “shall” is used to denote a requirement; the word “should” is used to denote a recommendation; and the word “may” is used to denote permission, neither a requirement nor a recommendation.

2.3 Definitions

age-related degradation: Degradation mechanisms often related to a length of time exposed to the environment. These include mechanisms such as corrosion, stress corrosion cracking, or fatigue and are usually dependent on the structure or component and the materials of construction.

aging management and life extension: A systematic program for managing the age-related degradation of structures and components in order to ensure that the structure or component is capable of providing its function through the facility’s operating life. This may entail condition monitoring, inspection, repairs, and/or replacement of components or subcomponents. This represents actions beyond normal maintenance.

³⁾ Numbers in brackets refer to corresponding numbers in Sec. 7, “References.”

⁴⁾ NUREG-2191 is a nuclear regulatory document that applies to NRC-regulated nuclear facilities and was used to support the evaluation of extending operation of the nuclear facility. Its reference in this standard is not intended to imply a regulatory requirement for application of this standard.

aging mechanism (or degradation mechanism): Any mechanism that can cause a structure or component (or its subcomponents) to degrade in its function. It usually refers to an attack on the materials of construction of the structure or component, whether metal, concrete, or polymer.

authority having jurisdiction: The organization or individual with responsibility for administering and enforcing the provisions of this standard.

condition monitoring: A process of monitoring parameters or observing general conditions of a structure or component in order to identify a significant change in the condition that is indicative of potential failure.

design basis: Information that identifies the specific functions to be performed by an SSC of a facility, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design.

long-lived SSCs: SSCs that are usually passive and designed to last the design life of the facility.

mitigation: Actions that are taken to arrest degradation if it starts to occur.

obsolescence: Refers to software or hardware of a component that is no longer supported by a supplier (usually the original equipment manufacturer).

performance monitoring: A process of monitoring parameters or quantitative measures that provide an understanding of how a component or system is performing against established thresholds.

predictive maintenance: Maintenance that uses the properties of the SSC in order to predict possible degradation or failure and to perform necessary maintenance to prevent failure.

preventive maintenance: Maintenance performed ahead of failure in order to prevent a structure or component from degrading significantly or failing.

safety class: Safety-class SSCs, including portions of process systems, whose preventive or mitigative function is necessary to limit radioactive hazardous material exposure to the public, as determined from safety analyses.

short-lived SSCs: Routine maintenance items, usually active (e.g., moving, rotating) components that are dealt with on a routine basis.

surveillance: Program of regular observance and tests to periodically assess the material condition of an SSC.

3 Aging Management Program overview

A comprehensive understanding of an SSC, its age-related degradation, and the effects of this degradation on its ability to perform its design functions is essential for developing a systematic aging management process. This understanding is derived from knowledge of the design basis (including applicable codes and regulatory requirements); the design and fabrication (material properties and specified service conditions); the operation and maintenance history (inspections and surveillances); and operating experience, including lessons learned.

There are thousands of SSCs that may affect the safety of the facility, all of which are subject to age-related degradation. The rates of SSC degradation and modes of failure vary considerably and are often discussed in terms of the equipment being either a short-lived or a long-lived active SSC that requires some type of maintenance intervention during its operating life, or a long-lived passive SSC where preventive maintenance is typically not planned over the operating life of the facility.

For short-lived and long-lived active SSCs, the common maintenance strategy is to identify failure modes from operating experience and to devise appropriate preventive maintenance tasks to prevent these failure modes. Such maintenance tasks typically monitor the condition; test functionality; replace consumables, piece parts, and components; and generally ensure that an SSC remains functional. In many cases, the age-related degradation of active and short-lived SSCs may be adequately addressed by existing maintenance, infrastructure, and engineering inspection and evaluation programs.

For long-lived passive SSCs, such as pressure boundary components, cables, and structures, preventive maintenance is typically not planned over the life of the facility. Long-lived passive SSCs are designed for fabrication with materials and by techniques that permit them to reach the end of facility life with an adequate safety margin still remaining. Premature failure of long-lived passive SSCs may occur due to shortcomings in design or manufacturing, the cumulative effect of operational errors, or unintended harsh environmental operating conditions that could lead to premature failure by unanticipated or unmitigated age-related degradation. Inspection, surveillance, and monitoring of these SSCs and the operating conditions to which they are exposed are therefore needed to verify that age-related degradation is controlled effectively for longer-term operation.

Development of an AMP consists of the following major processes:

- screening of facility SSCs:
 - initial screening of systems and structures;
 - selection of structures and components for subsequent review;
- review of aging mechanisms:
 - review of materials and operating environments;
 - identification of aging potential by comparison to known degradation mechanisms;
 - identification of locations where age-related degradation management may be needed;
- management of aging degradation mechanisms:
 - development of aging management plans.

4 Screening of facility SSCs

It is necessary to identify aging facilities or portions of facilities and/or processes that are needed to perform such facilities' intended operational function(s) for an extended period of time. This may include any major stand-alone component or structure (i.e., where the component or structure would be evaluated separate from a full system). This information is then evaluated and compared to the preestablished AMLE system selection criteria presented in Sec. 4.2. Selection includes systems that may be passive or not visible (e.g., buried, located in a secure location).

The screening process in Sec. 4.2 is applied to each facility system. A facility system is considered within the initial scope of an AMP when the system meets at least one of the following conditions:

- has been designated as a safety system;
- failure has a significant impact on facility safety performance;
- failure has a significant impact on continued operational performance;
- replacement cost represents a significant capital investment to the facility;
- has known equipment reliability issues.

In addition, it is at the discretion of facility management to identify and include any systems that have exhibited operational, maintenance, and/or performance reliability issues in the AMLE. Once all the facility systems have been identified and evaluated against the AMLE system screening criteria, the facility system down-selection process is complete. This more manageable list of systems and associated structures and components can now be further analyzed for age-related degradation and obsolescence issues.

4.1 Identification and selection of facility SSCs

4.1.1 Establishing screening and scoping criteria

Fig. 1 presents a process flow to identify and screen facility systems for further assessment and evaluation. Criteria are established to identify facility systems that are “in scope” for the AMLE process.

A facility may develop its own guidance for the selection of SSCs but should base selection on the importance of the SSC to the safe and reliable operation of the facility as well as the impact to facility resources such as labor and material costs.

The importance of an SSC to the safe operation of a facility is determined by formal classification, or categorization, of an SSC as safety related, safety important, or something similar prescribed by the facility. However, an SSC is also important when it has a function that directly impacts the operation of the facility. The AMLE SSC selection process considers this through inclusion of criteria based on cost of repair/replacements and amount of lost operation, or mission, time resulting from failure of the SSC. Because the level of impact—i.e., cost of repair and amount of facility outage time—is different for each facility, these selection criteria are determined by the facility.

The selection process recognizes that some SSCs may be included through discretion by management or subject matter expertise based on SSC performance causing burdens to operation or the staff in a cumulative manner and may not meet the thresholds established for the impact criteria. Alternatively, management may decide that there is some strategic value that warrants selection for aging management. This discretion is included in the final criterion of the selection process.

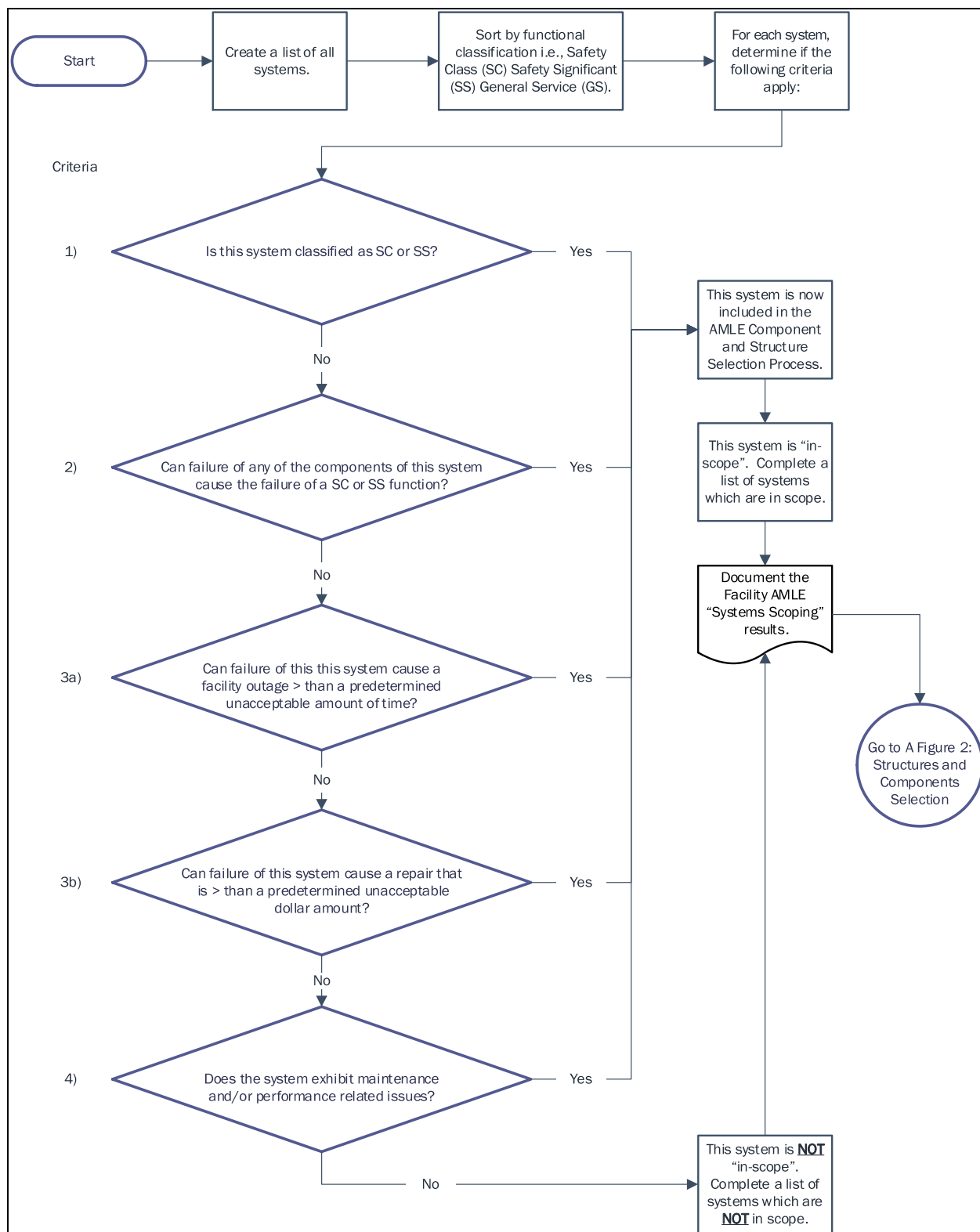


Figure 1 – AMLE facility system screening. This figure is adapted from Savannah River Nuclear Solutions [2] and used with their permission.

4.1.2 AMLE system screening

Fig. 1 illustrates a process to identify and screen facility systems for further assessment and evaluation. Results of the screening shall be documented, including justification for systems not identified as an “in-scope” system.

The AMLE process shall include a review of all systems associated with plant or facility operations to identify those with potential age-related degradation and a significant impact if age-related failures occur.

The system screening criteria are applied for each facility system. A system shall fall within the initial scope of the AMPs when the system meets one or more of the following criteria:

- (1) The system is functionally classified as safety class (SC) or safety significant (SS);
- (2) The system has the potential to prevent an SC or SS function from being met;
- (3) Reasonably anticipated failure of any part of the system is judged to have a significant negative impact on facility mission. The threshold of a significant negative impact is subjective and is established for each facility based on risk tolerance of the operation. For example,
 - (a) causes an unplanned facility processing outage of a predetermined time established by facility management (2 weeks, 1 month, etc.)

OR

 - (b) causes an unanticipated repair or replacement expense as determined by facility management (\$50,000, \$100,000, \$1,000,000, etc.);
- (4) The system exhibits operational, maintenance, and/or performance reliability issues.

4.1.3 AMLE structure and component selection

The first step in the identification and selection process (Sec. 4.1.2) addressed the screening of facility systems. Similar selection criteria to those used for the system evaluations are used to further select structures and components (see Fig. 2 for those “in-scope” systems that require aging analysis). For those structures and components not selected, a justification statement shall be provided.

After a system has been identified for inclusion in the AMLE process, further down-selection is performed by reviewing the structures and components for potential age-related degradation. A structure or component shall be selected for age-related degradation analysis if it meets one or more of the following criteria:

- (1) The structure or component is functionally classified as SC or SS;
- (2) The structure or component has the potential to prevent an SC or SS function from being met;
- (3) Reasonably anticipated failure of a structure or component is judged to have a significant negative impact on facility mission. The threshold of a significant negative impact is subjective and is established for each facility based on risk tolerance of the operation. For example,
 - (a) causes an unplanned facility processing outage of a predetermined time established by facility management (2 weeks, 1 month, etc.)

OR

- (b) causes an unanticipated repair or replacement expense as determined by facility management (\$50,000, \$100,000, \$1,000,000, etc.)⁵⁾;
- (4) The structure or component exhibits operational, maintenance, and/or performance reliability issues.

A structure or component is considered “in scope” and shall be evaluated for age-related degradation screening when it satisfies any one or more of the above screening criteria. All other structures or components are not “in scope” for this process.

4.2 Initial review of current AMPs

Credit can be taken for existing program activities associated with the management of nuclear facility aging including activities related to maintenance, infrastructure inspection, operations surveillances, and technical support programs such as structural integrity, nondestructive testing, condition monitoring of concrete structures, and cable aging.

Examples of some of the facility programs that can typically be credited as providing aging management are provided in Table 1.

Table 1 – Examples of facility programs related to an AMP

▪ Cable aging program
▪ Conduct of operations and maintenance
▪ Maintenance work control
▪ Master equipment list
▪ Materials shelf life program
▪ Predictive maintenance
▪ Preventive maintenance
▪ Quality assurance programs
▪ Safety analysis (e.g., DSA or SAR) upgrades
▪ Spare parts program
▪ SSC performance monitoring
▪ Structural integrity program
▪ System health reports

To determine if existing operational, maintenance, and engineering programs and procedures are sufficient to support structure and component aging management, three (3) additional questions can be asked regarding the structures and components considered to be in the scope of the AMLE. The questions address whether existing facility programs or procedures (including those in Table 1) effectively address specific aging management issues:

⁵⁾ The basis for these criteria is the same as that described in Sec. 4.1.2.