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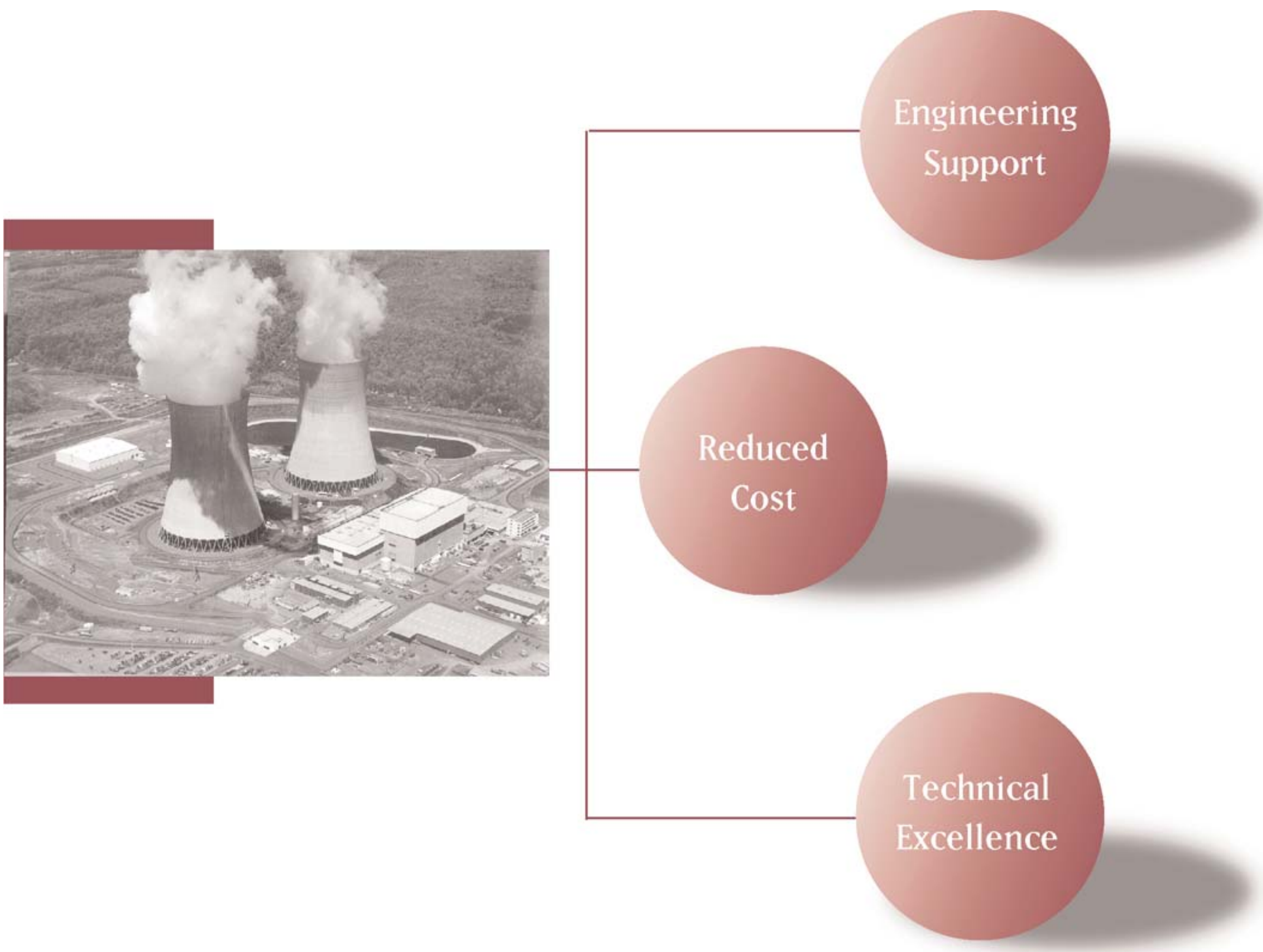
Plant Support Engineering: Guidelines for the Technical Evaluation of Replacement Items in Nuclear Power Plants

Revision 1

LICENSED MATERIAL

Technical Report



Plant Support Engineering: Guidelines for the Technical Evaluation of Replacement Items in Nuclear Power Plants

Revision 1

1008256

Final Report, July 2006

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CITATIONS

This report was prepared by

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This report describes research sponsored by EPRI.

The report is a corporate document that should be cited in the literature in the following manner:

Plant Support Engineering: Guidelines for the Technical Evaluation of Replacement Items in Nuclear Power Plants—Revision 1. EPRI, Palo Alto, CA: 2006. 1008256.

REPORT SUMMARY

Background

Most U.S. utilities with operating nuclear power plants frequently require replacement parts as well as components. However, the longer that nuclear power plants remain in operation, the greater the possibility that identical replacement parts and components have been discontinued. Furthermore, suppliers are increasingly unwilling to assist plants in researching replacement items for discontinued products and certifying the equivalence of those items with the originals. For help in acquiring replacement parts, owners may use this report, formerly NP-6406, which can be used in conjunction with the EPRI reports *Guideline for the Utilization of Commercial-Grade Items in Nuclear Safety-Related Applications (NCIG-07)* (NP-5652) and *Supplemental Guidance for the Application of EPRI Report NP-5652 on Commercial-Grade Items* (TR-102260).

Objective

- To provide guidelines for performing technical evaluations of replacement parts procured for nuclear power plants

Approach

In 1988, a joint EPRI/Nuclear Construction Issues Group (NCIG) committee initiated a project to develop guidelines in response to increasing industry emphasis on procuring equivalent replacement items for nuclear power plants. The committee formulated its guidelines in accordance with federal regulations contained in 10CFR50 Appendix B and related regulatory guides. As the specific regulatory basis for development of its guidelines, the committee used U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.33, Revision 2, dated February 1978, *Quality Assurance Program Requirements (Operational)*.

After the original report was issued, industry experience prompted EPRI-member utilities to form a task group to revise this guidance. The revisions were necessary to address current regulatory requirements (that is, 10CFR50.59) and to better reflect utility procurement practices.

Results

This report contains six major sections that provide a systematic approach to determining appropriate technical and quality requirements for replacement items. The technical evaluation methodology includes the following:

- Identification of the need for a technical evaluation
- Functional classifications of components and parts
- Analysis of failure modes and their effects

- Determination of a "like-for-like" or "alternate item" type of procurement
- Evaluation of equivalency for alternate items
- Specification of technical and quality procurement requirements

EPRI Perspective

To avoid impacting their licenses, nuclear utility owners must ensure that parts of equal quality are available for timely replacement. The guidelines in this report give utility owners a systematic approach for establishing technical and quality requirements of replacement items are consistent with the originals. In addition, information in this report can also be applied to the procurement of new items for plant modifications and nuclear services. Related EPRI reports include previously mentioned NP-5652 and TR-102260 as well as *Guidelines for Preparing Specifications for Nuclear Power Plants (NCIG-04)* (NP-5638).

Keywords

Alternate item procurement
Equivalency evaluation
Like-for-like procurement
Replacement item
Specification
Technical evaluation

ACKNOWLEDGMENTS

EPRI would like to thank the following individuals who participated in the task group for the revision of this report and provided valuable assistance and plant-specific information during its development:

Frank Strehle	Progress Energy
Bhavesh Patel	Progress Energy
Dennis Weaver	Constellation Energy Group
Jim Smart	Dominion Virginia Power
Stephen Greenwood	Dominion Virginia Power
George Kuhn	Exelon Corporation
Daniel Frantz	FirstEnergy Nuclear Operating Corp.
George Shampy	Nova Machine Products
Michael Tulay	Sequoia Consulting Group
Ed Wynne	TXU Power

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INTRODUCTION

1.1 Issue

During the mid-1980s, a continued need for engineering involvement in the procurement process for replacement items was emphasized at utilities owning or operating nuclear power plants. The specific guidance in existing documents did not provide utility technical staffs with clear direction to meet this increased demand. Factors contributing to this need included the following:

- The technical, reporting, and quality assurance (QA) program requirements necessary to comply with existing nuclear regulation constituted a significant activity for manufacturers and suppliers. With the decline in nuclear plant construction, the number of qualified nuclear suppliers continued to decrease.
- Nuclear power plants faced the likelihood of the unavailability of identical replacement components and parts the longer they remained in operation. The willingness of suppliers to accept nuclear utility purchase requirements that include the need for researching and certifying equivalency to discontinued products, evaluating changes in manufacturing processes, designs, and materials, and performing special inspections and tests had diminished.
- Isolated occurrences of substandard and fraudulent purchases further challenged existing nuclear industry controls.

The guidance in the original version of this report, EPRI report NP-6406 [1], was prepared to satisfy the following nuclear industry needs:

- A technical evaluation process for assuring that replacement items procured for nuclear power plants are equivalent to the original items
- A method for determining the design functions, functional safety classifications, and functional modes of replacement items
- Methods for determining the critical characteristics for design of replacement items that mitigate failures and contribute to proper functional performance
- Methods for specifying adequate technical and quality requirements in procurement documents to assure that proper replacement items are obtained

The Nuclear Construction Issues Group (NCIG), under the sponsorship of EPRI, developed the original version of this report to provide guidance for the technical evaluation of replacement items. The guidance was developed to be responsive to shifting industry conditions while maintaining regulatory conformance. Since the issuance of the original report, industry developments prompted EPRI-member utilities to form a task group to revise this guidance. The revisions were necessary to address current regulatory requirements (that is, 10CFR50.59) and to better reflect utility procurement practices.

1.2 Purpose

This report provides guidance for performing technical evaluations of replacement items as required by American National Standards Institute (ANSI) N18.7-1976, Section 5.2.13, "Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants," [2] as endorsed by U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.33, Revision 2, dated February 1978, "Quality Assurance Program Requirements (Operational)" [3]. This report is to be incorporated into the licensee's procurement process as the licensee deems appropriate.

1.3 Scope

This report sets forth an approach for performing technical evaluations of replacement items. These processes may also be used in the procurement of new items for plant modifications and nuclear services.

The methods and processes described in this report are generally concerned with the engineering or technical activities required to specify the technical and quality requirements in the generation of an adequate procurement document. This report should be used with the EPRI report *Guidelines for the Utilization of Commercial-Grade Items in Nuclear Safety-Related Applications (NCIG-07)* (NP-5652) [4] and ANSI N45.2.13, "Quality Assurance Requirements for the Control of Items and Services for Nuclear Power Plants" [5] to address both the specification and acceptance of commercial-grade items. These documents are helpful in defining the methods used in the verification of prescribed technical and quality requirements for basic components and commercial-grade items used as basic components. The interface between this report, EPRI report NP-5652, and ANSI N45.2.13 is shown in Figure 1-1.

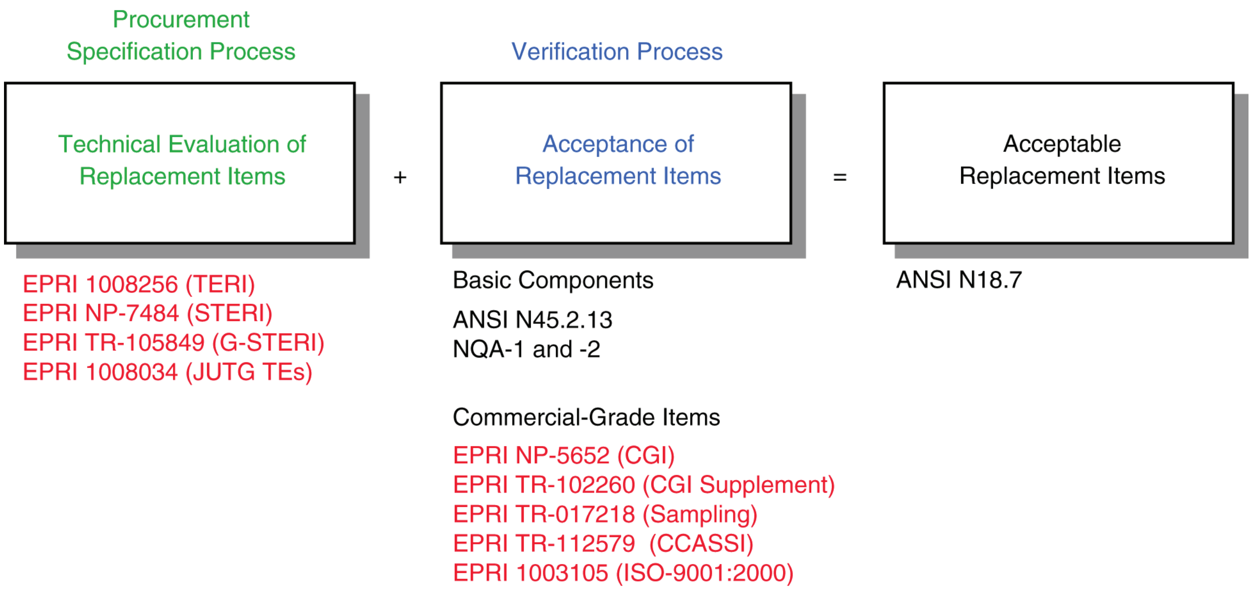

Figure 1-1
Procurement of Replacement Items

By properly applying the systematic technical evaluation process for replacement items described in this report, nuclear procurement programs should maintain the appropriate technical and quality requirements necessary for proper equipment specification.

1.4 Report Premises and Limitations

In the development of this report, certain basic premises and limitations were assumed. Care should be exercised to ensure that technical evaluations are conducted within the constraints described in this section.

1.4.1 Design Changes Versus Equivalent Changes

This report assumes that a plant-initiated design change is **not** required if the equivalency of the form, fit, function, and interchangeability (including seismic and environmental qualification requirements) of a replacement item has been established. The basis for this premise is that the plant's, system's, or component's design has not been altered.

Guidance regarding optimization of the change process and the processing of both design and equivalent changes is provided in the EPRI report *Guidelines for Optimizing the Engineering Change Process for Nuclear Power Plants, Revision 2* (1008254) [6].

1.4.2 Maintenance and Surveillance Activities

When performing the technical evaluation of replacement items, it is assumed that all required maintenance (that is, preventive and corrective) will be performed in accordance with proper procedures. The technical evaluation and acceptance process for a replacement item cannot compensate for improper maintenance practices (such as poor installation, missing parts, use beyond qualified life, and inappropriate application).

Surveillance requirements (such as operability checks, technical specification requirements, and post-maintenance testing) are also assumed to be performed in accordance with licensee requirements and plant procedures.

1.4.3 Q-List and Component Safety Classification

The technical evaluation for replacement items assumes that a "Q-list" identifying the safety-related systems and components in the nuclear power plant exists. This report is not intended as a stand-alone guide for developing Q-lists. It does, however, provide guidance for establishing functional safety classifications for components and parts when the Q-list does not contain sufficient detail to identify the safety classification or safety functions.

1.4.4 Engineering Judgment

Many of the decisions required in the performance of the technical evaluation processes in this report will be based on the knowledge and expertise of the personnel performing the evaluation. Individuals performing these evaluations must have the appropriate experience and/or training in design, manufacturing, equipment operation, maintenance, QA, and regulatory requirements to make these engineering judgments. This report provides guidance for the accomplishment of relevant tasks, but it is not intended to eliminate the need for sound technical decisions and judgment. The basis of engineering judgment made in the conduct of these evaluations should be documented.

1.4.5 Quality of Parts and Equipment Supplied

Manufacturers and suppliers are motivated to provide high-quality, reliable products that meet published specifications. During the technical evaluation process, the technical data in published specifications can be used to determine the suitability of a replacement item. However, suppliers must be carefully evaluated to ensure that only reputable suppliers are used. The acceptance process is then used to verify that the items received meet specified requirements and will subsequently perform their safety-related functions.

1.4.6 Technical and Quality Requirements

The amount of evaluation effort required and the extent to which specific technical and quality requirements are specified should be commensurate with the importance to safety of the item being evaluated.

1.4.7 Repetitive or Ongoing Item Procurement

When adequate technical and quality requirements for an item in a specific application have been established, it is not required to re-perform the evaluation unless a physical change has occurred in the item or it is intended for a different application.

1.4.8 Supporting Procedures

The guidance in this report should be implemented through detailed procedures specific to the licensee's QA program requirements.

1.5 Regulatory Basis

NCIG, under the sponsorship of EPRI, originally initiated work on this report in 1988 in response to the increasing industry emphasis in the area of procurement of replacement items in nuclear power plants. This report provides technical evaluation guidance based on federal regulations contained in 10CFR50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants" [7], NRC RG 1.123, Revision 1, dated July 1977, "Quality Assurance Requirements for Control of Procurement of Items and Services for Nuclear Power Plants" [8], and NRC RG 1.33, Revision 2, dated February 1978, "Quality Assurance Program Requirements (Operational)" [3].

The regulatory bases from 10CFR50, Appendix B applicable to this report can be found in Criteria III and IV of 10CFR50, Appendix B. Criterion III states in part:

> Measures shall be established to assure that applicable regulatory requirements and the design basis, as defined in §50.2 and as specified in the license application, for those structures, systems, and components to which this appendix applies are correctly translated into specifications, drawings, procedures, and instructions. These measures shall include provisions to assure that appropriate quality standards are specified and included in design documents and that deviations from such standards are controlled. Measures shall also be established for the selection and review for suitability of application of materials, parts, equipment, and processes that are essential to the safety-related functions of the structures, systems and components.

Criterion IV states in full:

> Measures shall be established to assure that applicable regulatory requirements, design bases, and other requirements that are necessary to assure adequate quality are suitably included or referenced in the documents for procurement of material, equipment, and services, whether purchased by the applicant or by its contractors or subcontractors. To the extent necessary, procurement documents shall require contractors or subcontractors to provide a quality assurance program consistent with the pertinent provisions of this appendix.

In addition, NRC RG 1.33, Revision 2, dated February 1978, "Quality Assurance Program Requirements (Operational)" [3], which endorses ANSI N18.7/ANS 3.2-1976, "Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants, Section 5.2.13," [2] states:

> …procedures shall be established and implemented to assure that purchased materials and components associated with safety-related structures or systems are purchased to specification and codes equivalent to those specified for the original equipment, or those specified by a properly reviewed and approved revision. In those cases where the original item or part is found to be commercially "off the shelf," or without specifically identified quality assurance requirements, spare or replacement parts may be similarly procured but care shall be exercised to assure at least equivalent performance. In those cases where the Quality Assurance requirements of he original item cannot be determined, an engineering evaluation shall be conducted by qualified individuals to establish the requirements and controls. This evaluation shall assure that interface, interchangeability, safety, fit and function requirements are not adversely affected or contrary to applicable regulatory or code requirements. The results of these evaluations shall be documented.

The engineering evaluation required by ANSI N18.7/ANS 3.2-1976 is the same as the technical evaluation described in this report.

1.6 Joint Utility Task Group Commercial-Grade Item Technical Evaluations

Since the original publication of this report, EPRI Plant Support Engineering (PSE) and the Joint Utility Task Group (JUTG) have developed 139 commercial-grade item evaluations for commonly procured commodity- and consumable-type items. Beginning in 1989, these evaluations were developed with input from technical working groups composed of licensee engineering personnel. Each technical evaluation typically includes the following information:

- Descriptions of the item's design and safety functions
- Limitations and restrictions regarding plant applications in terms of the item's effect on the seismic and/or environmental qualification of host equipment
- Critical characteristics for design (including the type of property or attribute and a brief description of the characteristic)
- A technical basis for selecting critical characteristics for acceptance

- Guidance for implementing each commercial-grade item acceptance method (including the identification of sources for each characteristic's acceptance criteria, means of verification, and typical sample size when testing is feasible)
- References and attachments of supporting drawings, illustrations, and graphics

The JUTG technical evaluations are provided to assist licensee procurement and engineering organizations when preparing plant-specific procurement specifications and commercial-grade item dedication plans. They are intended to be used as a technical reference representing the consensus of the respective technical working group and should not be used in place of licensee processes for performing these tasks.

Licensees are encouraged to evaluate each technical evaluation on a case-by-case basis to ensure that the information is appropriate for the given plant-specific application(s) in which the item will be installed.

1.7 Conversion Factors

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

Table 1-1
Conversion Factors Used in This Report

Parameter	English to Standard International Units
Length	1 in. = 25.4 mm 1 in. = 2.54 cm 1 ft = 0.305 m
Pressure	1 psig = 6.89 kPa 1 lb.ft/in^2 = 6.89 kPa
Radiation	1 rad = 0.01 grays
Temperature	°F = (°C * 9/5) + 32 °F = 1.8 (°C) + 32 °C = (°F - 32) * 5/9
Velocity	1 gal/min = 3.78 l/min
Weight	1 lb = 0.45 kg

2
TERMS, DEFINITIONS, AND ACRONYMS

This section defines terms used in this report in order to ensure a uniform understanding. In certain instances, the definitions may be unique to this guideline.

2.1 Terms and Definitions

Acceptance: The use of methods to produce objective evidence that provides reasonable assurance that the item received is the item specified.

Alternate item: A replacement item not physically identical to the original. These replacement items require an equivalency evaluation to ensure that the design function will be maintained.

Alternate item procurement: The replacement of an item with an item not physically identical to the original.

Assembly: A combination of subassemblies, components, or both that forms a workable unit (for example, control room panels, motor control centers, instrument and piping racks, and skid-mounted equipment).

Basic component: An item procured either as safety related or as a commercial-grade item that has been accepted and dedicated for safety-related application.

Bounded technical requirements: A subset of technical requirements that is established through engineering activities that translate the values chosen as reference bounds for design of controlling parameters (that is, the "design bases" as defined in 10CFR50.2) into specific requirements included in such documents as specifications, drawings, and other design-output documents [6].

Bounding conditions: Parameters that envelop the normal, abnormal, and accident environmental conditions an item is expected to meet during its lifetime in the plant (for example, temperature, humidity, and seismic response spectra).

Commercial-grade item: A structure, system, or component, or part thereof that affects its safety function and that was not designed and manufactured as a basic component. Commercial-grade items do not include items where the design and manufacturing process require in-process inspections and verifications to ensure that defects or failures to comply are identified and corrected (that is, one or more critical characteristics of the item cannot be verified) [24].

Component: A piece of equipment, such as a vessel, pump, valve, core support structure, relay, or circuit breaker, that is combined with other components to form an assembly. Components are typically designated with an identification number (for example, Tag No.).

Critical characteristics for design: Those properties or attributes that are essential for the item's form, fit, and functional performance. Critical characteristics for design are the identifiable and/or measurable attributes of a replacement that provide assurance that the replacement item will perform its design function. (See the discussion in Sections 3.4 and 3.6.)

Critical characteristics for acceptance: Identifiable and measurable attributes and variables of a commercial-grade item that, once verified, provide reasonable assurance that the item received is the item specified [3]. Note: Critical characteristics for acceptance are a subset of critical characteristics for design.

Credible failure mechanism: The manner in which an item may fail, degrading the item's ability to perform the component or system function under evaluation [9].

Design function: The operation that an item is required to perform to meet the component or system design basis.

Equivalency evaluation: A technical evaluation performed to confirm that an alternate replacement item (not identical to the original) will satisfactorily perform its design function.

Failure modes and effects analysis: An evaluation of an item's credible failure mechanisms and their effect on system or component function.

Failure mode: The effects or conditions that result from an item's credible failure mechanism.

Functional classification: An item's functional classification is either safety related, non-safety related, or augmented quality, as described in the following:

- Safety related item: A plant structure, system, component, or part necessary to ensure one of the following:
  - The integrity of the reactor coolant pressure boundary
  - The capability to shut down the reactor and maintain it in a safe shutdown condition
  - The capability to prevent or mitigate the consequence of accidents that could result in off-site radiation exposures comparable to those documented in 10CFR100.11, "Determination of Exclusion Area, Low Population Zone, and Population Center Distance" [10]
- Non-safety related item: An item that does not perform a safety-related function.
- Augmented quality items: Non-safety-related items for which the licensee has made a regulatory or design basis commitment, or—for plant-availability reason—the licensee has implemented special controls to ensure reliability. The augmented quality items are generally included within the scope of licensee quality assurance processes.

Functional mode: A component's functional mode is determined to be either active or passive based on the following definitions:

- Active component: A component in which a mechanical or electrical change of state is required to occur in order for the component to perform its safety-related function.
- Passive component: A component in which a mechanical or electrical change of state is not required to occur in order for the component to perform its safety-related function.

Identical item: An item that exhibits the same technical and physical characteristics (physically identical).

Item: Any level of unit assembly, including structures, systems, subsystems, subassembly, component, part, or material (definition from ANSI N45.2.10-1973, "Quality Assurance Terms and Definitions" [11]).

Like-for-like procurement: The replacement of an item with an identical item (for example, replacement in kind).

Part: Items from which a component is assembled (for example, resistors, capacitors, wires, connectors, transistors, lubricants, O-rings, springs, bearings, gaskets, bolting, and seals).

Q-list: A document identifying those structures, systems, or components for a nuclear power plant that are safety related.

Replacement item: An item that replaces an original or installed item that can be either identical to the original or an alternate.

Supplier: The organization that furnishes a replacement item. This could include an original equipment manufacturer, part manufacturer, or distributor.

2.2 Acronyms

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ANS	American Nuclear Society
DPDT	Double pole double throw
EPDM	Ethylene propylene diene modified
EPIX	Equipment Performance Information Exchange

FMEA	Failure modes and effects analysis
FSAR	Final safety analysis report
IEEE	Institute of Electrical and Electronic Engineers
INPO	Institute of Nuclear Power Operations
ISO	International Organization for Standardization
JUTG	Joint Utility Task Group
MSIV	Main steam isolation valve
NCIG	Nuclear Construction Issues Group
NRC	U.S. Nuclear Regulatory Commission
NSSS	Nuclear steam supply system
NUREG	Nuclear Regulatory Commission publication
OD	Outside diameter
P&ID	Piping and instrument diagram
PSE	Plant Support Engineering
QA	Quality assurance
QSPDS	Qualified safety parameter display system
RG	Regulatory Guide
SAR	Safety analysis report (used interchangeably with USAR or FSAR)
USAR	Updated safety analysis report

3 EVALUATION PROCESS FOR REPLACEMENT ITEMS

Figure 3-1 illustrates the generic process for the technical evaluation of replacement items for use in nuclear power plants. The user may bypass certain steps in the generic process where the required information has been developed or where the step is unnecessary.

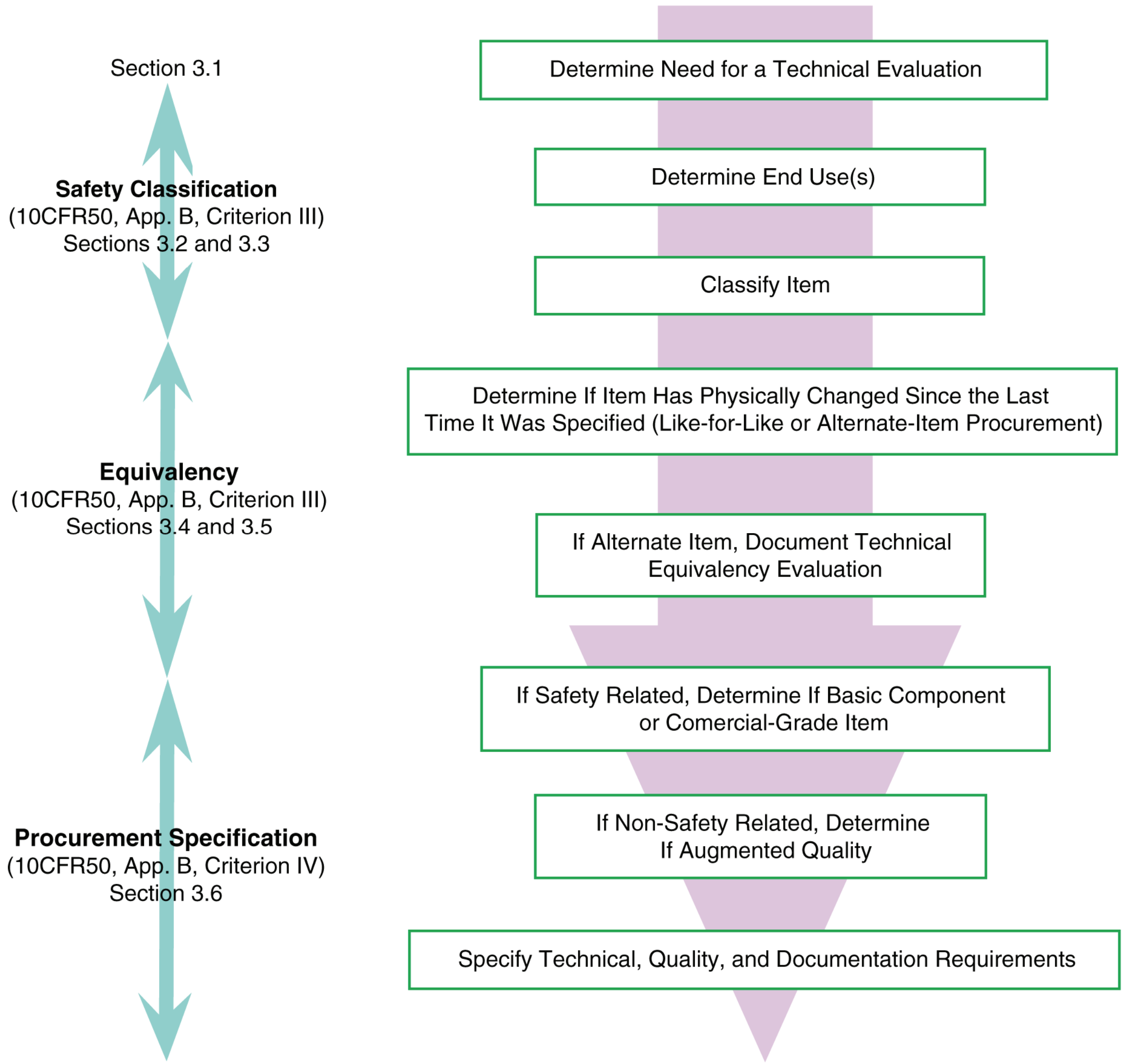

Figure 3-1
Generic Process for Technical Evaluation of Replacement Items

The process elements of the technical evaluation of replacement items that are described in this report include activities such as item safety classification, functional classification, and equivalency evaluation of alternate items that facilitate and support the subsequent specification of the item. As shown in Figure 3-1, these activities should be considered design activities and should be implemented to support Criterion III of 10CFR50, Appendix B. However, this does not mean that these activities constitute a design change or must meet the requirements of ANSI N45.2.11.

3.1 Need for a Technical Evaluation

The evaluation process begins when there is an identified need for additional technical information in order to obtain a replacement item.

Note: After an adequate set of procurement technical and quality requirements (described in Section 3.6 of this report) has been developed for an identical replacement item, repetitive technical evaluations are not required. Objective evidence should be available to support the adequacy of these technical and quality requirements for subsequent procurements.

3.1.1 Evaluation Process

Typically, a technical evaluation is required when one or more of the following conditions exists:

- A physical change has been identified in an item's interface, interchangeability, safety, fit, or functional requirements that requires an evaluation to determine its suitability for application.
- An alternate replacement item is being procured.
- The item to be procured is not addressed in the design specification, and functional classification, technical, or quality requirements are not available.
- New regulatory requirements have been imposed on the component, part, or system design.

Other situations that require a technical evaluation may occur during the procurement process, and the guidance in this report should be helpful in those cases.

3.1.2 Evaluation Factors

After the need for a technical evaluation has been established, specific conditions (such as availability of objective evidence) dictate the entry point into the generic process (see Figure 3-1). In many cases, information may already exist to sufficiently satisfy certain steps. Therefore, the user should determine which steps need to be performed for a particular procurement.

The total process described in this report provides for a condition where no functional, safety, or specification information is available. The process provides a means of developing the necessary technical data for an adequate procurement document.

3.2 Functional Classification of Components and Parts

This section provides guidance on determining the design functions, functional classification, and functional mode of components and parts. For components, the guidance incorporates the use of existing component classification information. It assists the user in determining the required information when the existing data do not provide the detail needed to perform a functional classification. For parts, the evaluation provides guidance for extending classification data to the part level based on the part's function and credible failure mechanism(s).

To assure proper application of appropriate technical and quality requirements, a classification system must be available to identify the varying levels of safety importance associated with a replacement item. This classification information is normally maintained in a design document such as a Q-list. The Q-list and/or other classification documents may not provide the detail required to determine if a particular function of a component is safety related or non-safety related.

In order to develop adequate information for performing subcomponent or part functional classification, the user must determine the component's function, functional classification, and functional mode. When this information is available from the Q-list, the user simply proceeds using this information. When the component's function, functional mode, and functional classification cannot be determined from the Q-list, an analysis must be performed.

A review of the design documentation—including plant drawings, safety analysis report (SAR), nuclear steam supply system (NSSS) safety analysis, system descriptions, design criteria, operating procedures, equipment/supplier data, or other documents as applicable—is required to determine system and component functions. The physical location of the item in the plant must also be identified for environmental and seismic qualification considerations.

Additional guidance regarding the classification of components and parts may be found in the EPRI report *Guidelines for the Safety Classification of Systems, Components, and Parts Used in Nuclear Power Plant Applications (NCIG-17)* (NP-6895) [12].

3.2.1 Evaluation Process for Functional Classification of Components

The component functions can be determined through a review of the system functions and the component's role in supporting those system functions. A list of typical component functions is included in Appendix A.

An evaluation of the component's role in performing the system safety functions should be made. Components found to have either safety functions or an effect on the performance of system safety functions should be classified as safety related.

Components that have no safety function or no effect on system safety functions may be further evaluated to determine if they are augmented quality. The augmented quality classification does not have clearly defined criteria. The scope of augmented quality items varies from plant to plant, depending on each licensee's commitments and/or other considerations (such as financial or critical to generation). Typically, augmented quality systems and components include those in the fire protection, radwaste, and post-accident monitoring systems. Items classified as augmented quality should always be considered a subset of the non-safety-related items.

3.2.1.1 Functional Mode Determination for Safety-Related Components

A functional mode should be determined for those components with safety-related functions. Each safety-related function of a component should be assigned an active or passive functional mode using the following criteria:

- An active component is one for which a mechanical or electrical change of state must occur in order for the component to perform its safety-related function.
- A passive component is one for which it is not necessary for a mechanical or electrical change of state to occur in order for the component to perform its safety-related function.

The purpose of the functional mode determination is to assist in the following:

- The determination of the functional classification of parts contained within a safety-related component
- The performance of a failure modes and effects analysis (FMEA)
- The determination of critical characteristics for design and technical/quality requirements of an item to be used in a specific application

When a safety-related component has been determined to be passive, only the parts affecting its structural or electrical integrity have a safety-related function.

3.2.1.2 Component Evaluation Factors

When the component's function, functional mode, and functional class determinations are completed, the following information should be available to confirm the conclusions and results:

- The functions that a component performs to support the operation of plant systems and other components
- The effect that spurious component operation has on the operation of plant systems and other components
- For electrical components, the effect that a failure of circuit integrity has on the operation of plant systems and components
- For mechanical components, the effect that a loss of pressure integrity or a mechanical failure has on the operation of plant systems and components

The following documents should provide the information needed to perform the evaluation:

- Piping and instrument diagrams (P&IDs) and isometrics
- Electrical schematics, one-line diagrams, elementaries, and instrument loop diagrams
- SAR, NSSS safety analyses, and system descriptions
- Technical specifications
- Design criteria manual and design basis manual
- Operating procedures, licensing commitments, and applicable codes and standards
- Others as applicable

3.2.2 Evaluation Process for Functional Classification of Parts

The part's functional classification depends on its parent component's functional classification (that is, safety related, augmented quality, or non-safety related), design functions, and functional mode as illustrated in Figure 3-2. (This figure has been updated using Figure 9.4-1 from the EPRI report NP-6895 [12].)

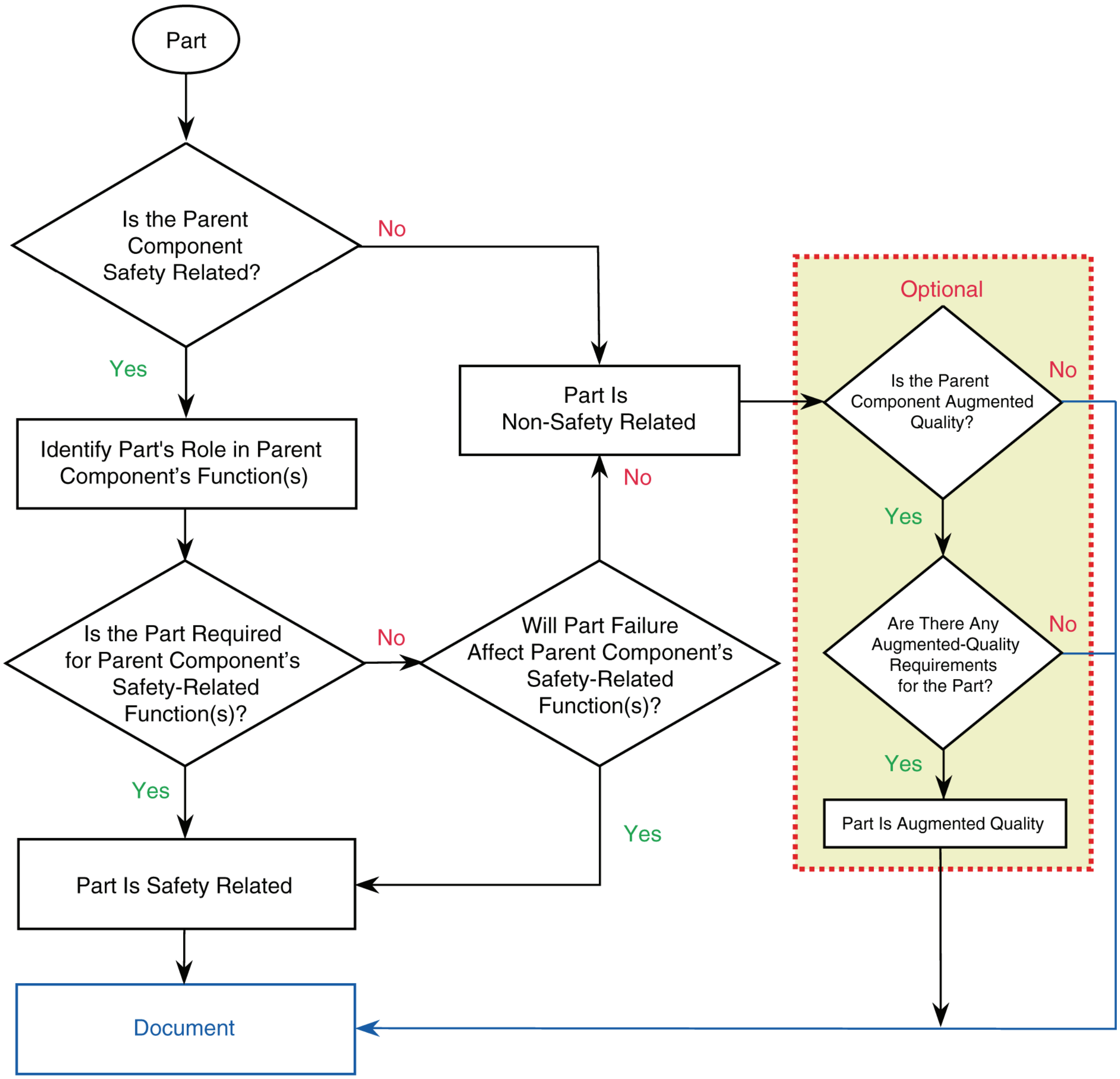

Figure 3-2
Process Diagram for Functional Classification of Parts

The part's functions and its contribution to the design functions of the component must be determined. Section 3.3 of this report can also be used to determine the effect that a part's credible failure mechanisms will have on the component's design function.

The parts in a safety-related component can be classified according to the following criteria:

- Is the part required in order for the component to carry out its safety-related functions? If not, the part may be non-safety related, but an additional evaluation is required. If the part is required for the component to carry out its safety function, the part is safety related.
- Will the part's credible failure mechanism(s) affect the component's safety-related functions? If not, the part is non-safety related. Parts with credible failure mechanisms that affect safety functions are safety related.

Optionally, the parts in an augmented-quality component can be classified as either augmented quality or non-safety related. The criteria for this classification vary from plant to plant, based on each licensee's commitments and business practices.

3.2.3 Documentation

The results of the component and part functional classification evaluation should be documented in accordance with the licensee's QA program. The documentation typically includes the following:

- Component identification (for example, tag number)
- Component function(s) and functional mode(s)
- Component functional classification
- Part identification
- Part function(s)
- Part failure mode(s) and mechanism(s)
- Part functional classification
- Basis for evaluation results and reference documents used

3.3 Failure Modes and Effects Analysis

A review can be made to ascertain the item's credible failure mechanisms and the effects those failure mechanisms have on the system or component functions (see Figure 3-3). The credible failure mechanism is the manner by which an item may fail, thereby degrading the item's ability to perform the component/system function under evaluation.

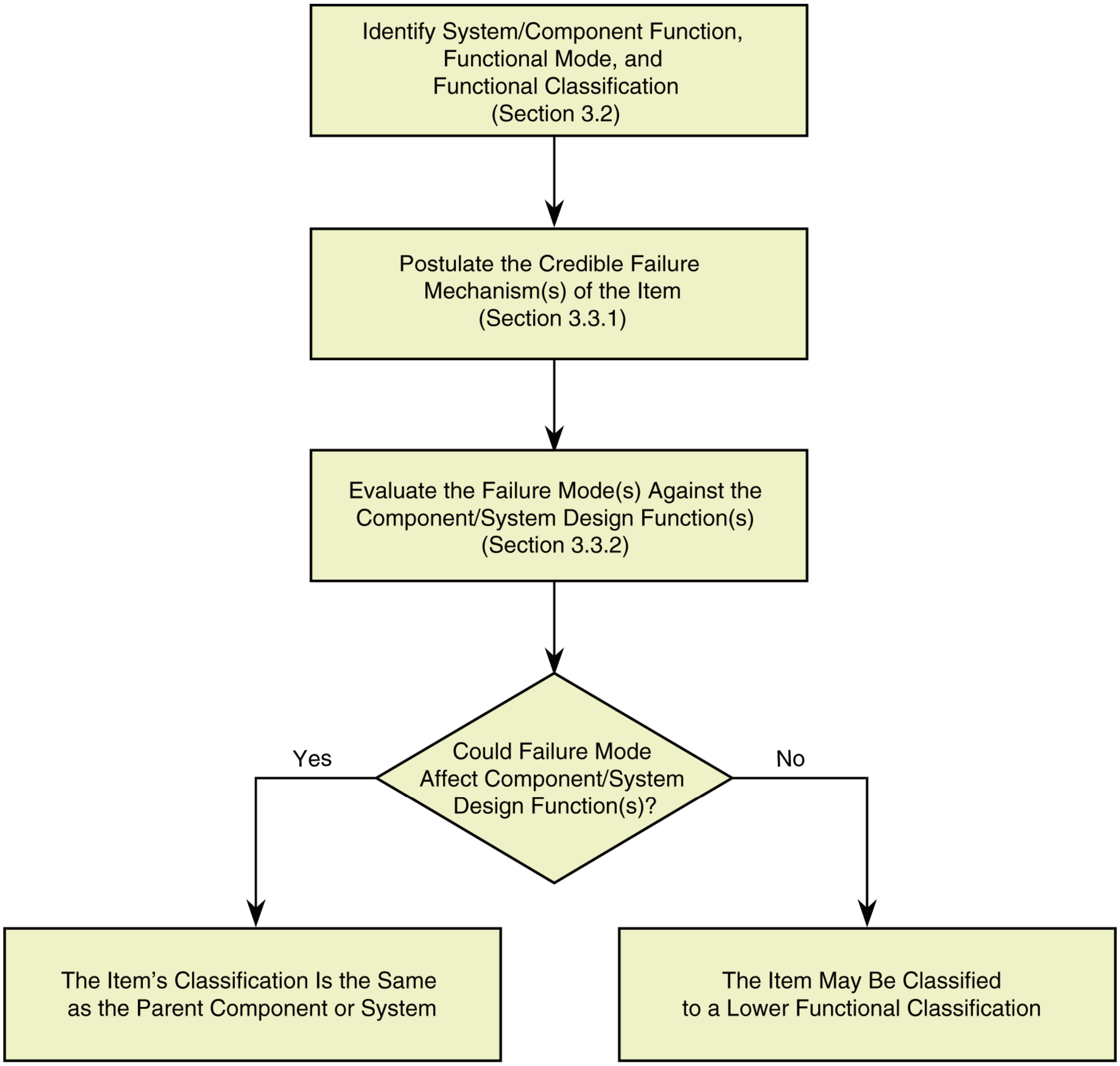

Figure 3-3
Failure Modes and Effects Analysis

The FMEA is an optional process when all items in a safety-related system are assumed to be safety related. It is, however, an effective tool in providing a basis for classifying items to a level below that of the parent components. It is also useful in selecting critical characteristics for design as described in Section 3.5.1. For a component-level FMEA, the "effect" scenarios evaluated use the system design functions. The parts-level FMEA evaluates the effect that part failures have on the component's design function.

When performing an FMEA, the following assumptions are made:

- Maintenance (corrective and preventive), surveillance, and parts replacement activities are performed properly in agreement with prescribed procedures. Human errors are not considered.
- All parts of a component (both safety and non-safety related) are present.

The FMEA and critical characteristics for design determination processes are generic to both components and parts. For this reason, the word "item" is used in this section to indicate this generic application.

3.3.1 Evaluation Process for Failure Modes and Effects Analysis

To perform an FMEA, identify the credible failure mechanisms of the item in the specific application or range of applications under consideration, using the functional information obtained in Section 3.2 and coupling it with the service conditions of the item. Appendix B of this report has been developed to aid in the determination of credible failure mechanisms.

Some specific failure mechanisms can be identified through the review of plant history (for example, nonconformances and work orders) and available industry data (for example, EPRI Preventative Maintenance Basis Database, Institute of Nuclear Power Operations [INPO] Equipment Performance Information Exchange [EPIX], NRC reports, NRC Bulletins and Information Notices, and Supplier Information Letters).

After the failure mechanisms have been identified, their effects can be evaluated using the following sources as input:

- P&IDs and isometrics
- Electrical schematics, one-line diagrams, elementaries, and instrument loop descriptions
- Technical specifications
- Supplier drawings and instruction manuals
- System descriptions
- SAR, particularly accident descriptions

The effect of the item's failure mechanisms should be evaluated in terms of component and systems functions, functional modes, and the functional classification. It may be possible to provide justification for items in safety-related and/or augmented-quality components/systems being classified as non-safety related. This justification is based on the item having no direct safety function and the failure mode having no effect on safety or augmented-quality functions.

An FMEA may be performed concurrently on both the component and its parts/subcomponents as a unit to provide consistency of results and to conserve time in performing these analyses.

3.3.2 Failure Modes

The failure modes of an item are identified by evaluating the item's credible failure mechanisms that are likely to occur under the item's service conditions (including normal and postulated accidents). Examples of failure mechanisms that may be considered, depending on specific conditions and/or applications, are the following as applicable:

- Fatigue fracture in a item when cyclic loading or high vibration is present
- Corrosion of items when environmental elements are present that contribute to galvanic or chemical reaction with the item's material of construction
- Short-to-ground failure in an electrical item when cyclic mechanical components may wear or erode, establishing a current path to ground

The following are examples of situations in which these same failure mechanisms would not be considered:

- Fatigue fracture in an item when cyclic loading does not occur or high vibration does not exist
- Corrosion when the item's environment is well within the established corrosive limits for the material of construction
- Short to ground when all circuit paths to ground are well insulated, even though the mechanical erosion does occur

Typical failure mechanisms and failure modes are listed in Appendix B of this report. The basis for determining that specific failure mechanisms are not credible should be documented and include the following as applicable:

- Approved calculations
- Documented industry studies
- Documented engineering judgment
- Results of qualification tests

Other factors that may influence credibility of failure mechanisms include surveillance activities and preventive maintenance on a frequency such that the probability of a failure is minimized by the monitoring, replacement, or refurbishment of the item. Proper maintenance is a means to mitigate failure mechanisms, but it is not a means to provide justification for changing an item's functional classification (that is, safety related to non-safety related).

Consider, for example, an O-ring in a harsh environment pressure transmitter. The O-ring is subject to loss of integrity (failure mode) because of radiation embrittlement (failure mechanism) at 10 to 15 years into its life for the specific application. However, scheduled preventive maintenance requires the O-ring to be replaced every five years. This failure mechanism would not be considered credible because replacement occurs well within the qualified life.

3.3.3 Documentation

The result of the FMEA should be documented in accordance with the licensee's QA program. The FMEA documentation typically includes the following:

- Item identification
- System/component functions
- Failure mechanisms considered
- Effect of the failure mechanism on system/component function (that is, failure modes)
- Basis for credible failure mechanism selection

3.4 Like-for-Like or Alternate-Item Evaluation

The determination of whether a procurement for a replacement item is like-for-like or alternate item should be established. Figure 3-4 illustrates that an equivalency evaluation is necessary when procuring alternate items to ensure that interface, interchangeability, safety, fit, and function are not adversely affected or contrary to applicable regulatory or code requirements. Equivalency evaluations are described in more detail in Section 3.5.

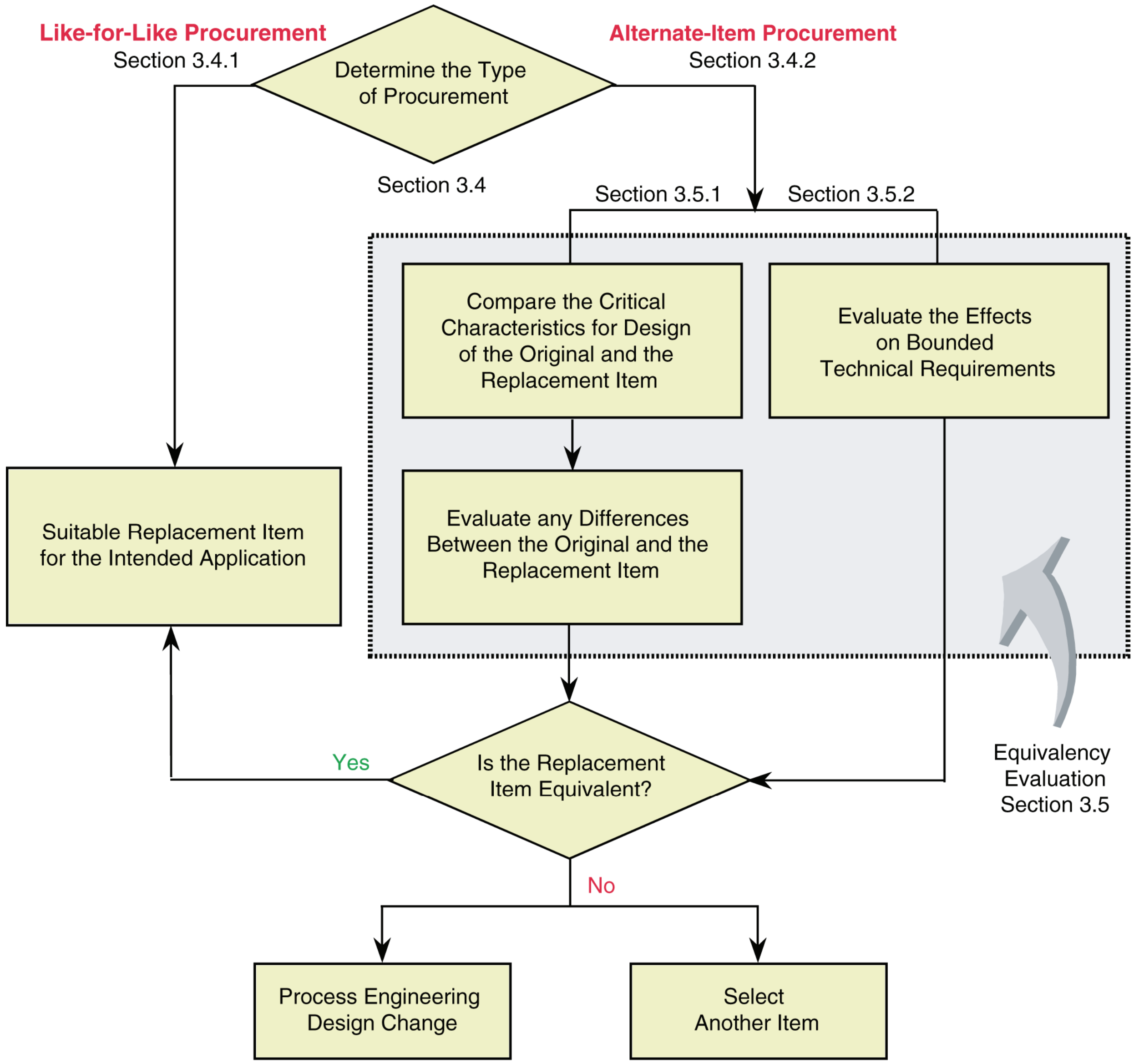

Figure 3-4
Determining the Procurement Scenario

3.4.1 Like-for-Like Procurement

A procurement for a replacement item is called like-for-like if the replacement item has not physically changed since the last time it was procured (that is, the replacement item is physically identical to the original). This determination is made through planned coordination with the supplier and by reviewing any existing technical and quality requirements for the item in its specific application(s).

The like-for-like evaluation is used to determine the degree of engineering evaluation necessary to specify the item correctly. If the design of the item has not changed, the technical and quality requirements can be specified using the guidance provided in Section 3.6. No further engineering evaluation is required.

In some instances, different procurement scenarios will not affect the validity of the like-for-like determination. These scenarios include the following:

- Items that have part or model number differences because of administrative changes
- Identical items purchased from alternative or sub-tier suppliers
- Items manufactured to industry standards but purchased from an alternative supplier

Care should be taken in these situations, however, because they are not guarantees that the item has not changed and is still suitable for its intended application. For instance, sometimes a part number change does in fact indicate a physical change to the item. Similarly, there are cases where a different supplier will introduce manufacturing processes or design modifications that physically alter the item. Care should be taken when the replacement item is made to an industry standard because of the potential variation in design or the design tolerances that are allowed under a given standard. In some cases, the requirements for suitability in a given plant application are more stringent than what are allowed in the national standard.

Additional guidance regarding the like-for-like determination is provided in the EPRI report *Supplemental Guidance for the Application of EPRI Report NP-5652 on Commercial-Grade Items* (TR-102260) [13].

3.4.2 Alternate-Item Procurement

When the replacement item is different from the original, the procurement is called alternate item, and an engineering evaluation is necessary to verify that the alternate replacement item is equivalent to the original and thus suitable for its intended application. As illustrated in Figure 3-4, this evaluation is referred to as an *equivalency evaluation*.

The extent and type of changes to the replacement item should be understood, recognizing that changes occur for a variety of reasons. The following are examples of alternate-item procurements:

- The current version of a torque switch is supplied with some of the internal piece parts made from plastic instead of the original material, which was phenolic.
- After refurbishment, a power supply contains subcomponents that are not identical to the originals.
- After repair and rewinding, a motor contains subcomponents that are not identical to the originals.
- To increase interchangeability with similar parts in another product line, the manufacturer changes the material of a replacement item for a valve from stainless steel to carbon steel.

In all of these examples, the licensee is ultimately responsible for demonstrating that the alternate replacement is equivalent to the original and therefore suitable for its intended application(s) in the plant.

When equivalency has been demonstrated for one application of an item, it is not automatically guaranteed for all similar applications. The equivalency evaluation must be directly related to the item's design function(s) and failure mechanism(s)/mode(s), including bounding conditions for environmental parameters during normal operation and post-accident conditions.

When the equivalency evaluation determines that an alternate item is not equivalent to the original item, the licensee can either process an engineering design change or select another item. These resulting design changes should be processed in accordance with each licensee's engineering change procedures.

Additional guidance on scoping and processing engineering changes is provided in the EPRI report *Guidelines for Optimizing the Engineering Change Process for Nuclear Power Plants, Revision 2* (1008254) [6].

3.5 Equivalency Evaluation for Alternate Items

This section describes two approaches for evaluating an alternate replacement item and determining whether it is equivalent to the original and, therefore, suitable for its intended application(s). A determination of the most appropriate approach should be based on the following factors:

- The type and extent of physical changes made to the alternate item
- The complexity of the replacement item
- The design function(s) of the replacement item
- End-use application(s) in the plant

3.5.1 Comparison of Critical Characteristics for Design

One approach for evaluating an alternate replacement item is to determine if the alternate item is equal to or better than the original. This is done by comparing the critical characteristics for design of the alternate item with the critical characteristics for design of the original item. *Critical characteristics for design* are properties or attributes that are essential for the item's form, fit, and functional performance. These are identifiable and/or measurable attributes of a replacement item that provide assurance that the replacement item will perform its design function. The process for determining critical characteristics for design is described in Section 3.5.2.

The term *critical characteristics* as used in the EPRI report *Guidelines for the Utilization of Commercial-Grade Items in Nuclear Safety-Related Applications* (NP-5652) [4] refers to the critical characteristics for acceptance (verification), which are based on the critical characteristics for design described in this report. Critical characteristics for acceptance are generally a subset of the critical characteristics for design.

Any differences identified during the critical characteristics for design comparison should be evaluated for their effect on the item's function(s) and failure mechanism(s)/mode(s) as identified in Sections 3.2 and 3.3 of this report. The critical characteristics for design comparison should include those design characteristics relating to an item's seismic and environmental qualifications, when applicable. The comparison may also require an understanding of the component design basis in order to determine whether the characteristics of the alternate item meet or exceed those of the original. For example, an alternate item having a heat-treated surface that is harder than the original may not be equivalent if the original item was designed to wear more quickly than were adjacent parts.

This approach is typically used in situations where the specifications and other design output documents for the replacement item are not controlled under the licensee's design control program, which is commonly the case for subcomponents and parts of plant components. Licensee design control for these items usually occurs at a higher level, such as the component or system level at which plant specifications were prepared during the design and construction process. Determination and evaluation of critical characteristics for design of replacement items that do not have specifications and drawings controlled within the licensee's design control program provide a basis for concluding whether the replacement items are equivalent to items currently installed in the plant.

3.5.1.1 Process for Determining Critical Characteristics for Design

The critical characteristics for design of an item can be derived from the item's function, functional classification, and the results of the FMEA, as shown in Figure 3-5. The FMEA process is an effective tool for deriving critical characteristics. It links the item's design function(s) to the attributes and characteristics necessary for it to perform those functions.

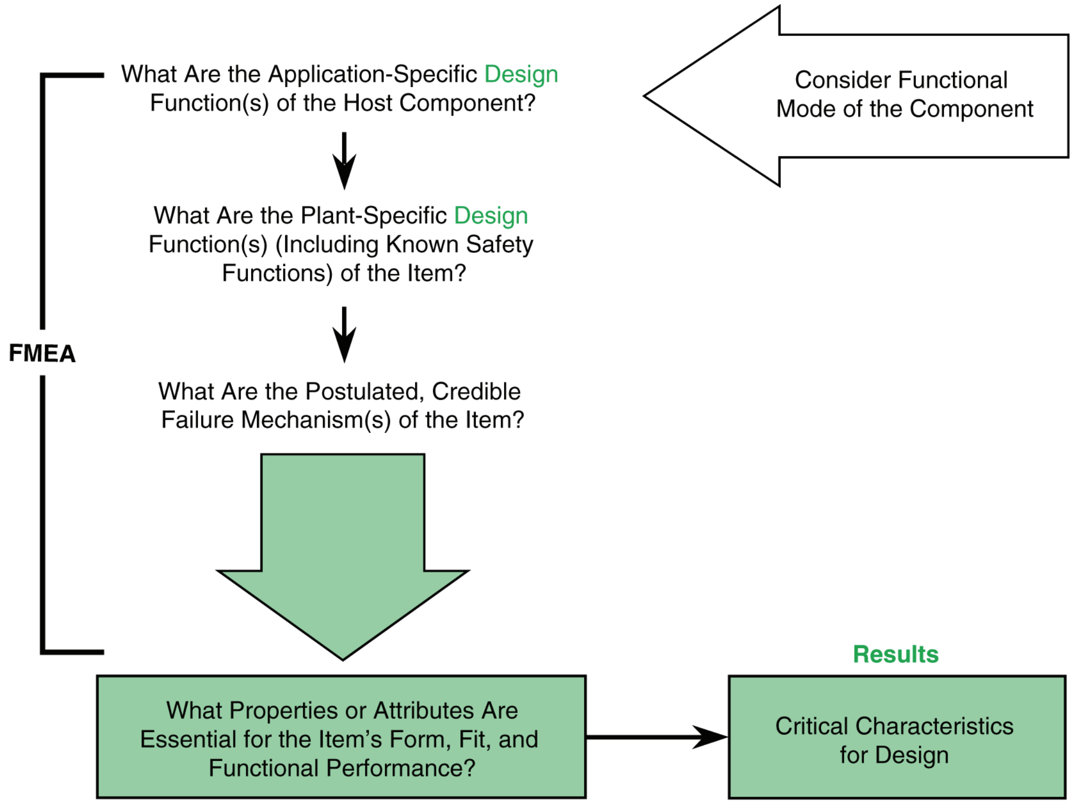

Figure 3-5
Process for Determining Critical Characteristics for Design

The bounding conditions for each function and failure mode, including environmental and seismic requirements, should be established. The bounding conditions are parameters such as temperature, humidity, exposure to elements, and radiation that influence an item's ability to perform its function or that contribute to its failure mechanisms.

The design characteristics that an item must possess in order to perform its function within these bounding conditions must then be determined. Design characteristics that mitigate failure mechanisms and bounding condition parameters should also be considered critical.

To ensure that the item will meet the plant's design requirements, critical characteristics for design should address the item's interaction with other parts, components, systems, and structures; the item's interchangeability; and the item's safety function, as a minimum. For a list of typical critical characteristics for design, see Appendix C.

3.5.1.2 Critical Characteristics for Design

To this point, the technical evaluation process has involved the less tangible concepts of item function, functional mode, and failure modes and effects. The determination of critical characteristics for design is the point in the evaluation process at which the identifiable and measurable attributes of an item are defined.

The following examples illustrate how critical characteristics for design (identifiable and measureable attributes) are established using the item's function, functional classification, and FEMA.

- An item that is required to maintain its structural integrity for function and is susceptible to mechanical creep as a failure mechanism has critical characteristics for design that include material composition, tensile strength, hardness, and ductility.
- An electrical component whose function is to provide a signal and to transform energy for transmission to other devices. The failure modes are loss of current signal and open circuit. The critical characteristics for design include input/output voltage, power rating, performance during under-voltage conditions/seismic events, and operating range.
- A fastener used in the housing mounting for the reactor control rod drive mechanism is required to maintain its structural integrity. The housing is subject to high vibration. Credible failure mechanisms include fracture due to tensile loading, vibration fatigue, and corrosion under environmental conditions. The critical characteristics for design include ultimate tensile strength, ductility, dimensions, and material chemical composition. Without the use of an FMEA, the ductility of the fastener material might not have been identified because, in most structural integrity evaluations, the tendency is to examine only tensile and shear loading. In this instance, the material ductility is the limiting design characteristic. Other grades of fastener material may exhibit better tensile, shear, and corrosion properties. However, the higher strength material exhibits a reduction in ductility that could lead to a fracture in this high-vibration application.

Additional guidance on determining critical characteristics for design is provided in the EPRI report *Supplemental Guidance for the Application of EPRI Report NP-5652 on Commercial-Grade Items* (TR-102260) [13].

The basis for the selection of critical characteristics for design should be documented in accordance with the licensee's QA program. The documentation may include the following:

- Identified critical characteristics
- The item's function, failure modes, and bounding conditions
- Information about how the item's failure modes and effects were used in determining the critical characteristics for design

3.5.2 Evaluating the Effects on Bounded Technical Requirements

Another approach for evaluating an alternate replacement item is to determine whether bounded technical requirements are adversely affected by the alternate item.

As described in the EPRI report 1008254 [6], this approach is most effective at the component or system level, where the design output documents (such as specifications and configuration drawings) are typically controlled by the licensee's design control program. The existing technical requirements included in those design output documents can be used to determine whether a replacement item is equivalent or requires a design change. Determination and comparison of critical characteristics for design, as such, are not required in these situations because the technical requirements related to the design basis functions and licensing basis requirements (such as design codes) have already been established through previous design activities and are included in the licensee's design output and licensing basis documents.

Guidance on evaluating alternate items using this approach is provided in the EPRI report 1008254 [6] and is not described in further detail in this report.

3.5.3 Generic Equivalency Evaluations

Since the original publication of this report, some licensees have had success in improving the efficiency of the equivalency evaluation process by planning and performing certain equivalency evaluations on a generic basis. A generic equivalency evaluation is based on the particular item's design function(s) in a given or worst-case application. Therefore, the end-use application establishes the bounded technical requirements or design basis requirements that the item must meet. The generic equivalency evaluation establishes the critical characteristics for design based on those design functions and plant application(s) on a generic basis but allows the actual design criteria (sometimes referred to as *design parameters*) to be identified and compared on a case-by-case basis. Generic equivalency evaluations have been successfully implemented for commodity-type items such as resistors, capacitors, O-rings, lubricants, fasteners, and, in some cases, even more complex devices such as relays and breakers.

An example of a generic equivalency evaluation for a gasket is presented to illustrate this concept. Gaskets are used in various applications in the plant, but they basically have the same design functions regardless of the application. For worst-case (harsh environment) applications, the critical characteristics for design include the following:

- Gasket material properties (which may include physical properties and resistance to temperature and radiation)
- Gasket dimensions (which may include thickness and cross-sectional configuration)
- Material hardness (which may include durometer hardness and elasticity)

Although the actual design criteria or parameters for each of these characteristics will vary depending on the size and type of gasket, the applicable critical characteristics do not change because they are based on the gasket's design functions in the worst-case application—not on its design, size, or type. Therefore, a generic equivalency evaluation can be established that consistently evaluates the same critical characteristics for a given commodity and its plant application(s) but allows for the comparison of design parameters for the specific items being evaluated.

The efficiency of this approach is achieved by identifying a set of critical characteristics for design that is applicable to a given commodity in a bounded set of applications, relieving the licensee of repeating this process on a case-by-case basis.

3.5.4 Documentation

Equivalency evaluations should be documented in accordance with the licensee's QA program. The documentation typically includes the following:

- Item identification
- Credible failure mechanism(s)
- Item function(s) and failure mode(s)
- Comparison of critical characteristics for design
- Basis for results
- Documents used

3.5.5 Applicability of Equivalency Evaluations

Each licensee should determine the extent to which equivalency evaluations may be appropriate for non-safety-related items. Factors that may be considered when making this determination include the following:

- Risk significance
- Importance to plant reliability and operating performance
- Procurement, maintenance, and/or installation costs
- Impact on plant personnel safety
- Importance to plant security

3.6 Specification of Technical and Quality Requirements

When the activities described in Sections 3.1 through 3.5 have been appropriately completed, sufficient information will have been gathered to allow for the generation of a procurement document to specify the replacement item.

The requirements for a procurement specification (see Figure 3-6) can be divided into the following three categories:

- Technical requirements
- Quality requirements
- Supplier documentation requirements

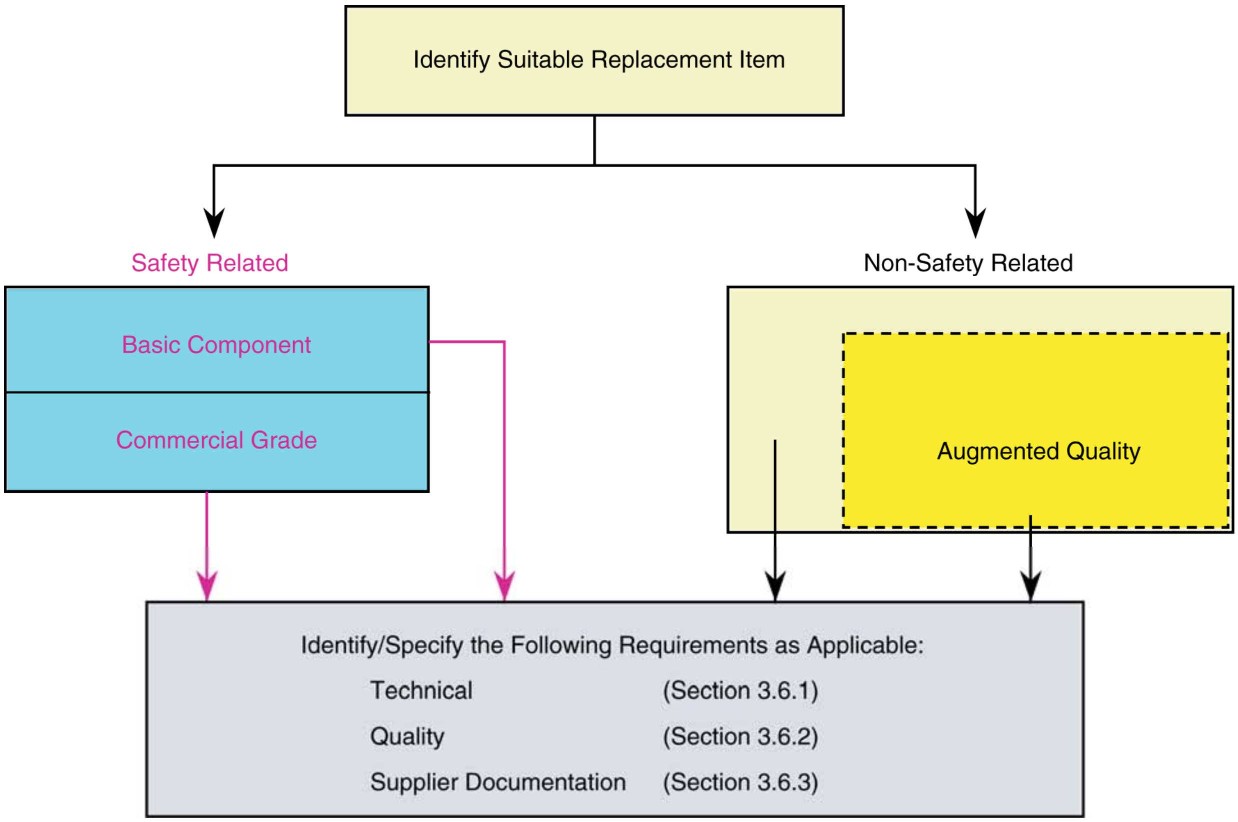

Figure 3-6
Specification of Procurement Requirements

3.6.1 Input Resources

The following sources, as applicable, may be used in the preparation of the procurement document:

- Item function and functional classification (see Section 3.2)
- Item FMEA (see Section 3.3)
- Item critical characteristics for design determination (see Section 3.5.1.1)
- Equivalency evaluation (see Section 3.5)
- Original component specification
- Component drawings
- Supplier manuals
- Seismic and environmental qualification reports
- Applicable NRC RGs
- NRC Bulletins and Information Notices

- Purchase orders (previous)
- Applicable industry standards
- Supplier correspondence

3.6.2 Technical Requirements

To ensure that an item is properly specified, a technical description of the item should be communicated to the supplier. The description should ensure that the item meets its design and qualification requirements. Sections 3.1 through 3.5 have been provided to aid in determining the technical requirements through an in-depth analysis of the item function, functional classification, credible failure mechanisms, failure modes, and critical characteristics for design. The technical requirements specified in the procurement document should directly relate to the results of this analysis.

In those cases in which a like-for-like procurement is being processed without a detailed technical evaluation, the technical requirements of the item must be sufficient to ensure that the replacement item is physically identical to the original.

For an alternate-item procurement, the technical requirements must be sufficient to ensure that the item is specified within the evaluated differences as described in Section 3.5.

Typically, the technical description will consist of the following applicable requirements:

- Part numbers, model numbers, and mark numbers.
- Noun description of the items with modifiers sufficient to distinguish the item from other similar items (for example, “1-K ohm ±5%, 5-watt, axial-lead, wire-wound resistor” versus “resistor”). Catalog descriptions may be used.
- Plant-specific or supplier drawings and revision level.
- Industry codes and standards, including applicable revision level. The specific applicable sections of codes and standards should be referenced whenever possible.
- Qualification parameters to maintain compliance to a qualification report or environmental and seismic conditions.
- Plant-specific conditions.
- Material specifications.
- Storage requirements to prevent degradation.
- Shelf life requirements.
- Storage maintenance requirements.

The technical requirements of an item are usually the same regardless of the supplier. However, when procuring an identical item from the original equipment supplier, it may not be necessary to list all of the technical requirements to effectively communicate the requirements of the proper item. The extent of the technical description included in the procurement document is dictated by the procurement conditions, the role of the supplier in the equipment design, the complexity of the item, the item's role in performing safety functions, manufacturing processes used in the item's production, and the bounding conditions that the item is required to satisfy.

When determining the technical requirements, ensure that the item specified has not been excluded from nuclear use due to inherent design or performance flaws. Excluded items are usually identified in NRC Bulletins and Information Notices, 10CFR21 reports, Supplier Information Letters, and INPO EPIX.

3.6.3 Quality Requirements

The quality requirements of an item are developed and specified in the procurement document in order to invoke the necessary supplier controls over manufacturing, design, and purchasing activities to ensure that the technical requirements are met.

Quality requirements do not take the place of or substitute for technical requirements. Products that are technically inadequate can be produced under an acceptable quality program, but they will remain technically inadequate for the application.

The quality requirements specified for an item are contingent on the item's role in performing safety functions, complexity in design, manufacturing processes for production qualification requirements, and special processes. Specific quality requirements may be imposed to focus resources on controlling the item's critical characteristics for design.

When specifying an item's quality requirements, it is necessary to understand the supplier's use of sub-suppliers and material sources in order to ensure that appropriate quality requirements are passed on and specified. The licensee's specific quality commitments from its QA program and SAR must be included, as necessary, to ensure compliance with regulatory requirements.

The quality requirements for commercial-grade items used in nuclear safety-related applications require special consideration. Commercial-grade purchases should not have nuclear unique standards (that is, 10CFR50, Appendix B and 10CFR21) imposed in the purchase documents. However, special quality requirements may be required. See the EPRI report *Guideline for the Utilization of Commercial-Grade Items In Nuclear Safety-Related Applications* (NP-5652) for additional guidance on this topic [4].

The quality requirements specified on the procurement document typically include the following:

- QA program requirements such as:
  - ANSI N45.2, "Quality Assurance Program Requirements for Nuclear Power Plants" [14]
  - 10CFR50 Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Processing Plants" [7]
  - American Society of Mechanical Engineers (ASME) Section III, NCA 3800, "Metallic Material Organization's Quality System Program" [15]

  - ANSI/ASME NQA-1, "Quality Assurance Program Requirements for Nuclear Facilities" [16]
  - ISO-9001, "Quality Management Systems–Requirements" [17]
  - IEEE-467, "Quality Assurance Program Requirements for the Design and Manufacture of Class 1E Instrumentation and Electric Equipment for Nuclear Power Generating Stations" [18]
  - Licensee QA program manuals
  - Supplier's approved commercial quality program manuals
  - A listing of specific QA program requirements

  The option selected must meet regulatory requirements, as a minimum.

- Source inspections (including witness and hold points): These should be specified for manufacturing processes affecting the critical characteristic for design for which the quality cannot be confirmed by other available methods. (For guidance on the other methods available, see ANSI N45.2.13, "Quality Assurance Requirements for the Control of Items and Services for Nuclear Power Plants" [5] and EPRI report NP-5652 [4].)
- Special quality requirements: These should be tailored to the critical characteristic for design, such as the performance of tests and inspections by the supplier. For example, penetrant testing may be required to verify weld quality, or a performance test may be required to verify the head and capacity of a pump. Special quality requirements can be imposed on a commercial supplier because these types of requirements are used in many non-nuclear applications.

Other special quality requirements may include qualification testing, access requirements for inspection/audit/surveillance, personnel qualification and certification, defect reporting according to 10CFR21 for nuclear suppliers, acceptance according to EPRI report NP-5652, or performance of sub-supplier's inspection/audit/surveillance/sampling according to established procedures or recognized standards. The quality requirements specified should be commensurate with the technical requirements specified.

3.6.4 Supplier Documentation Requirements

The documentation required to furnish objective evidence that the technical and quality requirements of items have been met should be specified. Supplier documentation may also be specified to provide confirmation of equivalency for an alternate replacement item or to identify discrete differences to facilitate the evaluation of an alternate item by the licensee. Documentation should be considered a tool in the verification of an item's technical adequacy and quality compliance but should not be used without confirmation of its validity (see EPRI NP-5652 [4], ANSI N45.2.13 [5], or ANSI N45.2.2 [19]).

Supplier documentation requirements should correlate with the specified technical and quality requirements and be specific as to their content. Care should be taken not to request excessive or meaningless documents such as invalidated Certificates of Conformance or test reports that are not applicable to the item.

Certificates of Conformance should avoid generalized statements, such as “This item meets the requirements of the purchase document.” Rather, Certificates of Conformance should contain specific statements, such as “These items were sample tested in accordance with MIL-STD-105E and verified to meet the tensile strength requirements of ASME SA 193 Grade B7. Test results are available for review.”

The types of supplier documentation typically specified should include, as applicable, the following:

- Supplier drawings, procedures, and specifications
- Supplier instruction manuals
- Qualification reports
- Certified material test reports
- Nondestructive test reports
- Personnel certifications
- Inspection reports
- QA manuals
- Performance test reports
- Certificates of Conformance/Compliance

Retention time of records should be specified. The quality and legibility of the records should be specified, where necessary, to ensure future reproduction capability.

3.7 Acceptance Requirements

As illustrated in Figure 1-1 of this report, the acceptance process is performed in conjunction with the technical evaluation to provide assurance that a replacement item is acceptable and will perform its design functions.

The acceptance requirements of an item should be planned and identified by the licensee. These requirements need not be specified in the procurement document but should be developed during the specification of the technical and quality requirements in order to provide continuity.

Acceptance requirements of an item should be commensurate with the item’s technical and quality requirements, the item’s critical characteristics for design, the supplier’s approved QA program, and the objective evidence available to support the item’s quality. The purpose of the item’s acceptance requirements is to provide reasonable assurance that the item received is the item specified.

Critical characteristics for acceptance are based on an item's critical characteristics for design. Critical characteristics for acceptance are attributes of an item that, once verified, provide reasonable assurance that the item meets specified requirements and subsequently will perform its safety-related functions. A critical characteristic for design may take a different form than a critical characteristic for acceptance. For example, the critical characteristics for design of an item may be its shear and tensile strengths and ductility. The critical characteristics for acceptance could be markings and material hardness, which can provide reasonable assurance that the material is conforming to its specification. Not all critical characteristics for design identified in technical evaluations require an associated critical characteristic for acceptance. Only a sub-set of those need to be verified to provide reasonable assurance that an item meets specified requirements and will perform its safety-related function(s).

Additional guidance regarding the acceptance process can be found in the following documents:

- ANSI N45.2.13, "Quality Assurance Requirements for the Control of Items and Services for Nuclear Power Plants" [5]
- EPRI report NP-5652, *Guideline for the Utilization of Commercial-Grade Items In Nuclear Safety-Related Applications* [4]
- EPRI report TR-017218, *Guideline for the Utilization of Sampling Plans for Commercial-Grade Item Acceptance* [20]
- EPRI report TR-102260, *Supplemental Guidance for the Application of EPRI Report NP-5652 on Commercial-Grade Items* [13]
- EPRI report 1003105, *Dedicating Commercial-Grade Items Procured from ISO 9000 Suppliers* [21]

Certain acceptance activities may be used for augmented-quality and non-safety-related items, as deemed necessary by each licensee.

Acceptance requirements should be planned and identified as applicable, using one or more of the following activities:

- Audits, surveys, and surveillances to verify that quality program requirements are implemented
- Source inspections and surveillances to verify the item's manufacturing process, technical and quality requirements, and critical characteristics
- Receipt inspections and performance tests to verify the physical and performance characteristics of an item (sampling may be used)
- Review of objective documentation to verify conformance of manufacturing process controls to industry codes, standards, specifications, and qualification tests

4
EXAMPLES OF SPECIFIC APPLICATIONS

This section provides guidance on the technical evaluation of replacement items by illustrating specific examples of the evaluation methodologies. These examples demonstrate the generic process for the technical evaluation by addressing all or part (as necessary) of the following steps:

1. Need for a technical evaluation
2. Functional classification of components and parts
3. Failure modes and effects analysis
4. Like-for-like or alternate-item evaluation
5. Equivalency evaluation for alternate items
6. Specification of technical and quality requirements

The examples provided are illustrative in nature and are not intended to be specific to any plant application. The examples should be used only as a guide for implementation of the technical evaluation and other processes involved. Boundary conditions, product data, application criteria, and failure modes may not represent actual conditions encountered.

In addition, these examples do not reflect design changes, safety reviews, or license amendments that may be involved due to plant-specific procedures or licensing commitments (see Section 1.4.1).

The following summarizes the nine illustrative examples included in this section:

- Power supply module: A licensee is evaluating the option to procure a 40-V regulated power supply module through the original commercial-grade manufacturer. Past procurements have been from the original supplier who maintained a 10CFR50 Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants” program. A technical evaluation is required to enable dedication of the item procured from the commercial-grade manufacturer. For this example, every element of the technical evaluation process has been exercised, including an FMEA.
- Elevator chain: A licensee is procuring an elevator chain, used to raise and lower a circuit breaker within safety-related switchgear into its test position, as a non-safety-related item. An evaluation is required to justify the functional classification of this item as non-safety related.
- Molded-case circuit breaker: A two-pole molded-case circuit breaker is no longer available. The breaker is being replaced with a three-pole breaker. The two circuit breakers are clearly not identical, and a technical evaluation is required to demonstrate equivalency.

- Pressure transmitter: A pressure transmitter (used in several applications with differing environments) is no longer available as originally purchased. The linear meter used for pressure indication has been replaced with a different model. A technical evaluation is required to justify use of the pressure transmitter in a different application.
- Main door gasket: The main door gasket for a containment air lock was originally made of silicone rubber. The replacement gasket is available only in ethylene propylene diene modified. The material change requires a technical evaluation to demonstrate equivalency.
- Timing relay: A timing relay, which controls the delay in the application or removal of power to safety-related equipment, is no longer available from the manufacturer. A replacement item has been identified and needs to be evaluated as an alternate item.
- Operational amplifier: An operational amplifier, used in the input filter board of the qualified safety parameter display system, is available from two manufacturers. Both manufacturers are potential suppliers. A technical evaluation is required to justify procurement of this item from the alternate supplier.
- Limit switch lever arm: A qualified limit switch lever arm used on the main steam isolation valve (MSIV) is no longer offered by the manufacturer. A potential replacement, with some dimensional differences, is available. An evaluation is required to demonstrate equivalency of the replacement.
- Relief valve: A relief valve on the emergency diesel cooling water system has had its model number changed. A licensee plans to procure the valve and a number of spare parts for future use in the plant. A technical evaluation is required. This example provides an illustration of part functional classification.

4.1 Power Supply Module

Application: Nuclear Steam Supply System and Reactor Protection System Information

Manufacturer: Campower
Identification No.: PM-38.0-0.05 AF/40.0

Supplier: Nuclearest
Identification No.: Model 137-122 40-Vdc Loop Power Supply
Style No. 669A518H01
Part No. 426019H0l

4.1.1 Need for a Technical Evaluation

The licensee has a need to obtain a power supply for a 40-Vdc regulated power supply module for a Nuclearest Model 137-122 40-Vdc loop power supply assembly. The licensee has determined that the power supply is available from Campower (the original commercial-grade manufacturer) under Part No. PM-38.0-0.05 AF/40.0 or from Nuclearest (the original approved supplier) under Part No. 426019H01. The licensee has determined that the power supply meets the definition of a commercial-grade item. Therefore, the following options are available:

- Buy the power supply from the original supplier who maintains a 10CFR50 Appendix B QA program. Verify through audit that the original supplier has maintained traceability of the item changes and an adequate commercial-grade dedication program.
- Perform a technical evaluation of the power supply, procure from the original commercial-grade manufacturer, and dedicate the power supply.
- Return the power supplies to the original commercial-grade manufacturer for repair, and dedicate the repair service.
- Obtain internal parts for the power supplies and repair the power supplies on-site, using a qualified maintenance technician. This would also require classification and dedication of the procured items.

The licensee elected to proceed with the second option, based on availability of the power supplies as well as economic considerations.

4.1.2 Functional Classification of Components and Parts

Component function and functional mode: These single-loop power supply assemblies furnish regulated electrical power for flow, level, and pressure instrumentation used in the monitoring and protection of accumulator tanks and pressurizer and safety injection pumps in the reactor coolant and safety injection systems. The plant Q-list does not specifically list these power supplies but does state that the instruments fed by them are safety related. These power supply assemblies are used in the plant for pressurizer pressure protection and indication, pressurizer level protection, and safety injection system flow indication with safety injection system accumulator pressure indication. The component function is to provide power and electrical isolation and to maintain circuit integrity. Each of these functions is performed in a safety-related Class 1E circuit.

Based on this information, the power supply assemblies perform safety-related functions. As a result, the functional classification for the power supply is safety related. The isolation function is performed by a dropout relay when the power supply is deenergized. The functional mode for the power supply assembly is active because a change of state is required for the relay to perform its safety function.

4.1.3 Failure Modes and Effects Analysis

The credible failure mechanisms/modes for these power supplies are open circuit, short circuit, and seizure of the dropout relay. In addition, loop accuracy is verified by surveillance. Finally, three other loops provide this identical information, and any drift would be detected immediately. The effects of these failure modes are the following:

- Open circuit: Loss of level indication and protection actuation loop on accumulator tanks and pressurizer; loss of flow indication on safety injection pumps.
- Short circuit: Same as open circuit.
- Seizure of dropout relay: Loss of isolation between Class 1E and Non-1E circuits on faulted conditions.
- Unregulated power (drift over-/under-voltage): Failure to provide adequate regulated power is not considered a credible failure based on the fixed wiring and circuitry of the regulator.

4.1.4 Like-for-Like or Alternate Item Evaluation

Through licensee contract with Campower, Nuclearest contracted with Campower to furnish power supply modules with the same model and part numbers used in the Nuclearest Model 137-122 40-Vdc power supply assembly. The contract did not include special requirements, such as special tests and/or inspections, other than to affix the nameplate bearing the power supply assembly model and part numbers. As stated in Section 4.1.1, this power supply module is manufactured by Campower and identified by the Campower Model No. PM-38.0-0.05 AF/40.0 and has Nuclearest Part No. 426019H0l affixed to the power supply module.

In addition, the licensee researched the Nuclearest purchase order and specification from the original plant documentation and found no requirements that would indicate any alteration by Nuclearest from the original power supply.

4.1.5 Equivalency Evaluation for Alternate Items

To achieve additional confidence that the item had not physically changed, the critical characteristics for design were identified and a comparison made as illustrated next. For each function and failure mode, the critical characteristics were determined as shown in Table 4-1.

Table 4-1
Critical Characteristics for Design

Function	Critical Characteristics for Design
Provide power	Voltage rating/accuracy (40.0 Vdc ±0.2 V) Source: Design Criteria Manual Instrument Loop Calculations
Provide electrical isolation	Operability of dropout relay Source: Design Criteria Manual Supplier Technical Bulletin
Maintain circuit integrity	Performance during over-/under-voltage conditions and seismic event Source: SAR
Failure Mechanism/Mode	
Open circuit	Same as those for maintaining circuit integrity
Short circuit	Same as those for maintaining circuit integrity
Seizure of dropout relay	Same as those for providing electrical isolation

A review of the test requirements (see Table 4-2) indicates that the power supplies will exhibit these critical characteristics for design under conditions equal to or exceeding the plant applications.

Table 4-2
MIL Specifications
(Source: Campower Catalog 19-85-Ab)

Specification	Description
MIL-STD-202C	Test Method for Electronic and Electrical Component Parts
MIL-STD-461A	Electromagnetic Interface Characteristics Requirements for Equipment
MIL-STD-462F	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-S-901C	Shock Tests, High-Impact (HI), Shipboard Machinery, Equipment and Systems, Requirements
MIL-E-5272C	Environmental Testing, Aeronautical and Associated Equipment, General Specification
MIL-E-5400H	Electronic Equipment Aerospace General Specification
MIL-1-6181D	Interference Control Requirements, Aircraft Equipment
MIL-E-1640OF	Electronic Equipment, Naval Ship and Shore, General Specification
MIL-1-16910C	Interference Measurement, Electromagnetic Methods, and Limits

Note: Care should be taken to ensure that the proper revision of reference documents is used at the time of evaluation.

The comparison of critical characteristics for design is performed with the following results:

- Power rating: 20 Watts
- Voltage rating/accuracy: Tested and verified in MIL-STD-202C to be 40 V ±0.2 V
- Operability of dropout relay: Tested and verified in MIL-STD-462F
- Performance during over-/under-voltage conditions: Verified to maintain voltage rating at 40 Vdc ±0.2 V during vibration testing in accordance with MIL-S-901C, which exceeded plant seismic response spectra.

The Campower supply module Model No. PM-38.0-0.05 AF/40.0 is identical to the Nuclearest power supply module Part No. 426019H0l and Style No. 669A518H0l. The original component's basic construction (for example, shape and structure as distinguished from its material), the dimensional characteristics, the component's function, and the process of control and assurance activities (for example, design, fabrication, and material) are not changed (references: Nuclearest - application data for Model 137-122 40-Vdc power supply and Campower MIL qualified modular power supplies, catalog 8220-0003).

Based on this information, this is a like-for-like procurement of an identical item, and the interface, interchangeability, safety, fit, and functional requirements are not adversely affected.

4.1.6 Specification of Technical and Quality Requirements

The licensee specified the following technical and quality requirements in the procurement document:

- Technical requirements
  - Campower part number and catalog description
  - Right of access for commercial-grade survey

  The licensee determined that the power supplies had no shelf life or storage maintenance requirements. The packaging and storage requirements (provided by Campower) to ensure protection from the effects of temperature extremes, humidity and vapors, "g" forces, physical damage, and airborne contamination were determined to be adequate to maintain the power supplies in transit and storage. The power supplies did not appear on the utility's "excluded items list" (that is, a compilation of items appearing in NRC Bulletins and Information Notices or other industry notices).

- Quality requirements

  The licensee has reviewed the commercial quality program of Campower and found it to be adequate to control the critical characteristics for design. The quality requirements involved are the following:

  – Campower QA program manual
  – Campower Catalog No. 19-85-Ab and associated MIL Specifications (see Table 4-2)
  – Notification of any changes in quality program requirements and catalog specification

- Supplier documentation requirements

  The licensee requested certification to the MIL Specifications listed in Table 4-2 and to the accepted commercial quality program.

4.1.7 Acceptance Requirements

The licensee performed a commercial-grade survey of Campower to verify that the MIL Specifications in Table 4-2 were being met and that objective evidence was available to confirm acceptable implementation of Campower's quality program. The critical characteristics for acceptance were then specified as part number verification, visual configuration comparison to the catalog, nameplate data verification, and review of the Certificate of Conformance to the MIL Specifications listed in Table 4-2.

4.2 Elevator Chain

Application: Powerex Model M-26 Switchgear, 4.16-KV, 1200-A

Manufacturer: Powerex
Identification No.: Bulletin PXH-1802; Fig. 32 Ref. 22

Supplier: Powerex
Identification No.: Bulletin PXH-1802; Fig. 32 Ref. 22

4.2.1 Need for a Technical Evaluation

The elevator chain was originally procured as part of a safety-related component. The licensee desires to procure the elevator chain as a non-safety-related item. A technical evaluation is needed to procure it as a non-safety-related item.

4.2.2 Functional Classification of Components and Parts

The elevator chain is a part of a circuit breaker that is a component of the emergency switchgear. The elevator chain is used to raise or lower the circuit breaker from or to the test position within the switchgear enclosure. When the circuit breaker is in the operating position, the elevator chain does not assist the circuit breaker in performing its safety function. An analysis of the credible failure mechanism (that is, fracture or deformation) does not produce an effect or failure that would prevent the breaker from performing its safety-related function. Based on this information, the only component function for the elevator chain is to raise and lower the circuit breaker for testing purposes.

The licensee has no special license or quality requirements pertaining to this switchgear, thereby eliminating augmented quality requirements. Based on this information, the part's functional classification is non-safety related.

4.2.3 Failure Modes and Effects Analysis

Because this item is non-safety related and identical to the original, it is not necessary to determine the critical characteristics for design in order to adequately specify the item.

4.2.4 Like-for-Like or Alternate-Item Evaluation

The part number for the safety-related and non-safety-related elevator chain is the same. The part is unchanged and identical to that procured as safety related, based on a review of the Breaker Technical Manual. Therefore, this is a like-for-like procurement of an identical item, and no equivalency evaluation is required.

4.2.5 Equivalency Evaluation for Alternate Items

Because this item is non-safety related and identical to the original, the critical characteristics for design determination are not necessary to adequately specify the item.

4.2.6 Specification of Technical and Quality Requirements

The licensee specified the following technical and quality requirements in the procurement document:

- Technical requirements

  Part number and catalog description

- Quality requirements

  None

- Supplier documentation requirements

  None

4.2.7 Acceptance Requirements

Because this item is non-safety related, acceptance requirements were limited to standard receipt inspection according to licensee procedures.

4.3 Molded-Case Circuit Breaker

Application:	Mild environment, seismically qualified
Manufacturer:	Rightway/1TE
Identification No.:	EF2-A030
Supplier:	Corporatex, Inc.
Identification No.:	EF2-A030

4.3.1 Need for a Technical Evaluation

Molded-case circuit breaker EF2-A030 is no longer available. The licensee plans to replace the EF2-A030 (two-pole unit) molded-case circuit breaker with an EF3-A030 (three-pole unit) molded-case circuit breaker. Given that these two items are not identical, a technical evaluation must be conducted for the molded-case circuit breaker in order to demonstrate equivalency.

4.3.2 Functional Classification of Components and Parts

For the purposes of this example, the molded-case circuit breaker is used for a Class 1E circuit in a mild environment and mounted in an enclosure classified seismic Category 1.

The circuit breaker is a necessary component to ensure the capability to shut down the reactor and maintain it in a safe shutdown condition and/or prevent or mitigate the consequences of accidents. Based on this information, the functional classification is safety related. The molded-case circuit breaker maintains circuit integrity and/or responds to a command from a protection device (change of state). Therefore, the molded-case circuit breaker's functions are change of state and/or maintenance of circuit integrity, and the functional mode for the circuit breaker is active.

4.3.3 Failure Modes and Effects Analysis

The subsequent evaluation of differences between the original and replacement item did not warrant an FMEA.

4.3.4 Like-for-Like or Alternate-Item Evaluation

In this case, the licensee plans to replace the EF2-A030 molded-case circuit breaker. The replacement item is not identical to the original item; therefore, this is an alternate-item procurement.

4.3.5 Equivalency Evaluation for Alternate Items

The critical characteristics for design of this breaker are its frame size, tripping range, number of poles, current and voltage rating, weight and mounting (for seismic considerations), and performance characteristics. A comparison of these characteristics for the original and replacement breaker is shown in Table 4-3.

Table 4-3
Comparison of Original and Replacement Breakers

Critical Characteristics for Design	Original	Replacement	Comparison
Frame size	EF*	EF*	Same frame
Number of poles	2*	3*	No effect on this application
Type and range	A*	a*	Both are standard instantaneous range complete circuit breakers
Continuous current ampere rating of breaker	30*	30*	Same rating
Weight	10.4 lb	10.9 lb	Replacement is 0.5 lb heavier
Time/current curve			Identical

* Included as part of identification number

The EF3-A030 circuit breaker is a three-pole unit and is approximately 0.5 lb heavier than the two-pole unit. A letter issued by the supplier to the licensee states that the seismic and environmental performance of the three-pole EF3-A030 breaker is equivalent to that of the two-pole EF2-A030 breaker. Furthermore, both circuit breakers have the same mounting configuration and are qualified to IEEE 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations" [22] and IEEE 344-1975, "IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations" [23], using the plant-specific parameters. In addition, both circuit breakers have the same frame size, tripping ranges, material, and standards for manufacturing. The 0.5-lb weight difference was less than 10% of the total weight of the breaker, and all other key parameters were identical. For all stress levels, the seismic mounting calculations were far less than 90% of allowable (therefore, margins were far greater than 10%), and an increase in deflections was considered negligible. Based on this information, the replacement molded-case circuit breaker EF3-A030 will perform the desired safety-related functions because the bounded technical requirements are not adversely affected. The EF3-A030 molded-case circuit breaker is an equivalent replacement for the EF2-A030 molded-case circuit breaker.

4.3.6 Specification of Technical and Quality Requirements

The licensee specified the following technical and quality requirements in the procurement document:

- Technical requirements
  - Part number and catalog description
  - Specification of critical characteristics for design of frame size, tripping range, and current rating
  - Specification of conformance to IEEE 323-1974 and IEEE 344-1975 qualification test reports
  - Shipping and storage according to ANSI N45.2.2, Level B requirements

  The licensee determined that the circuit breakers had no shelf life or in-storage maintenance requirements.
- Quality requirements
  - 10CFR50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants"
  - Underwriters Laboratory Listed
  - 10CFR21, "Reporting of Defects and Noncompliances" [24]
- Supplier documentation requirements

  Certificate of Conformance to the specific technical and quality requirements

4.3.7 Acceptance Requirements

The licensee identified the following acceptance requirements for the circuit breaker:

- Part number verification
- Operability test at installation to verify trip settings
- Review of Certificate of Conformance

4.4 Pressure Transmitter

Application: Main steam tunnel, feedwater lines, and waste gas decay tank

Manufacturer: Brand X
Identification No.: PG3000-10M-48-12-11

Supplier: John Most
Identification No.: W33214

4.4.1 Need for a Technical Evaluation

Pressure transmitter type PG3000-10M-48-12-11, located in valve actuating lines, is no longer available. The "-11" in the identification number designates an MA128 linear meter, which has been discontinued by the manufacturer and replaced by an MA134 linear meter, designated as "-19." During the course of procuring the transmitter, it was determined that it is used in three applications, each having a different environment: on the feedwater line, in the main steam tunnel with high temperatures and humidity, and on the waste gas decay tank with high radiation exposure. The licensee has decided to select a replacement that is suitable for the three applications. A technical evaluation must be conducted for installation of Brand X Pressure Transmitter PG3000-10M-48-12-19 in place of PG3000-10M-48-12-11 in each of the three applications in order to confirm that interface, interchangeability, safety, fit, and functional performance will not be adversely affected. This evaluation should bound the requirements of all three applications if one model is to be used.

4.4.2 Functional Classification of Components and Parts

In all applications, these pressure transmitters will provide a signal for local indication purposes. As a result, the component function is local indication. The pressure transmitter is isolated mechanically and electrically from all safety-related equipment.

In all three applications, failure or malfunction of the pressure transmitter will not affect the integrity of the reactor coolant pressure boundary or the capability to shut down the reactor and maintain it in a safe shutdown condition or to prevent or mitigate the consequences of accidents. The transmitter does not have any credible failure mode that can result in the inability of the main steam system, feedwater system, or waste gas decay tank to perform their safety-related functions. As a result, the pressure transmitter does not perform a safety-related function.

All three applications do, however, require quality programs. The transmitter will be classified as augmented quality because the licensee has committed to apply specific quality controls in the radwaste, main steam, and feedwater systems.

4.4.3 Failure Modes and Effects Analysis

Because the pressure transmitter performs no safety function and is isolated mechanically and electrically from the safety systems, an FMEA is not necessary.

4.4.4 Like-for-Like or Alternate-Item Evaluation

The original linear meter, MA128, has been discontinued and replaced by MA134, which is an upgraded version. The replacement meter is not identical to the original meter; therefore, this is an alternate-item procurement.

4.4.5 Equivalency Evaluation for Alternate Items

Based on the function of the transmitter and its range of environments, critical characteristics for design are the following:

- Materials
- Temperature rating
- Type of transmitter
- Metallic construction
- Range
- Accuracy

Because the transmitter is used in three applications, the bounding conditions (worst case) will be used for each of the parameters shown in Table 4-4.

Table 4-4
Environmental Conditions

Condition	Feedwater Line	Main Steam Tunnel	Waste Gas Decay Tank
Temperature	170°F	200°F	170°F
Relative humidity	90%	100%	90%
Radiation	$<10^1$ rads	$<10^1$ rads	10^7 rads

Therefore, the bounding conditions are 200°F, 100% relative humidity, and 10^7 rads.

According to a licensee telephone conference memorandum with the manufacturer and supplier, the MA134 is an upgraded version of MA128, is functionally and physically identical to the MA128, and differs in electrical parts only. These meters perform alike and are terminated in the same manner. The comparison between the original and replacement transmitters is shown in Table 4-5.

Table 4-5
Comparison of Original and Replacement Transmitters

Critical Characteristics for Design	Original (MA128)	Replacement (MA134)	Comparison
Type	Sealed adjustable gage transmitter with accuracy of +0.25%	Sealed adjustable gage transmitter with accuracy of +0.25%	Same
Pressure range	0–2000 psig	0–2000 psig	Same
Mounting	Factory mount	Factory mount	Same
Materials	316 SS end cap 316 SS diaphragm Silicone fluid	316 SS end cap 316 SS diaphragm Silicone fluid	Same
Scale	0–100 linear scale	0–100 linear scale	Same
Terminations			Same
Weight	~4.0 lb	~4.0 lb	Same
Function			Same
Physical configuration			Same
Electrical parts			Different; no functional effect
Temperature	0–250°F maximum	0–250°F maximum	Equivalent

In addition, results of qualification tests performed by the supplier on the MA134 model show that, after radiation aging equivalent to 10^7 rads, the transmitter remains operational in a 3000°F, 100% relative humidity environment for 24 hours. This exceeds any postulated conditions that could occur in the installed applications.

Based on the comparison of critical characteristics for design (Table 4-5), licensee conversations with the manufacturer/supplier, and the results of the qualification tests, the replacement transmitter will satisfactorily perform its function in all three applications. Therefore, it is an equivalent replacement item.

4.4.6 Specification of Technical and Quality Requirements

The pressure transmitter is non-safety related with QA requirements (that is, augmented quality). There are no unique characteristics that require special design, manufacturing, control, testing, or documentation processes that prevent it from being identified by a catalog number. Therefore, the pressure transmitter can be ordered using Catalog Number PG3000-10M-48-12-19.

The licensee specified the following technical and quality requirements in the procurement document:

- Technical requirements
  - Part number and catalog description
  - Reference to qualification test
- Quality requirements

  Quality program meeting licensee's quality program requirements
- Supplier documentation requirements

  Certificate of Conformance to qualification reports

4.4.7 Acceptance Requirements

The licensee identified the following acceptance requirements for the transmitter:

- Part number verification
- Review of Certificate of Conformance
- Survey of supplier quality program controls

4.5 Main Door Gasket

Application:	Air locks
Manufacturer: **Identification No.:**	Not applicable
Supplier: **Identification No.:**	MGM Service, Inc. 135-18

4.5.1 Need for a Technical Evaluation

The supplier subassembly drawing for the air locks identifies the main door gasket material as silicone rubber; the air lock operation manual shows the material as ethylene propylene diene modified (EPDM) rubber. Silicone rubber is no longer available for the application, and EPDM rubber is a new material substitution. This change in material for the gasket requires a technical evaluation to confirm that interface, interchangeability, safety, fit, and functional performance will not be adversely affected.

4.5.2 Functional Classification of Components and Parts

The purpose of the air lock is to provide a passageway for personnel entering or leaving the containment building. The component function is containment building isolation, and the gasket is designed to provide a seal.

Failure or malfunction of the main door gasket will not affect the integrity of the reactor coolant pressure boundary; however, it may affect the control of any radioactivity released from the reactor containment building. Therefore, the failure or malfunction of the main door gasket may affect the capability to mitigate the consequences of an accident, which could result in off-site exposures as described in 10CFR100 [25].

The gasket performs a safety-related function because its failure could prevent the air lock's safety function from being accomplished. As a result, the functional classification for the gasket is safety related.

4.5.3 Failure Modes and Effects Analysis

The gasket's credible failure mechanisms, which could result in the inability of the air locks to perform their safety-related function, are cracking and embrittlement. These failure mechanisms result in failure modes of loss of seal and loss of resiliency.

4.5.4 Like-for-Like or Alternate-Item Evaluation

Because the differences between the original and replacement gasket (that is, in material of construction) may impact the critical characteristics for design and hence the likelihood of failure, the item is not physically identical to the original and must be considered an alternate-item procurement.

4.5.5 Equivalency Evaluation for Alternate Items

Critical characteristics for design that mitigate cracking or embrittlement are strength, resilience, and resistance to various environmental factors (for example, abrasion, weathering, radiation, harsh environment, and aging). The ability to make an effective seal would require material composition, size, configuration, and thickness as critical characteristics for design.

Based on a review of material properties, the replacement material is not identical to the original material; both gaskets are identical in all other respects. The comparison of the EPDM to the silicone rubber is shown in Tables 4-6 through 4-9. In general, the elastomers are limited to applications of only moderate temperature and pressure and require comparatively low seating stress to make an effective seal.

Table 4-6
General Comparison of Silicone and Ethylene Propylene Diene Modified

Silicone	Ethylene Propylene Diene Modified
Silicone rubbers are resistant to water, ozone, and sunlight and can withstand very low or high temperatures. Silicone is odorless and tasteless and will not support bacterial life. It should not be exposed to pressure, steam, oils, gasoline, or other hydrocarbons.	Ethylene propylene (and the diene-modified form, EPDM) has good mechanical properties and is resistant to aging, weathering, ozone, oxygen, steam, and water. It is especially resistant to phosphate-ester-based hydraulic fluids but is not recommended for use with petroleum-based fluids.

Table 4-7
Comparison of Relative Performance of Silicone and Ethylene Propylene Diene Modified

Performance Property	Silicone	Ethylene Propylene Diene Modified
Abrasion	Poor	Good
Compression set	Excellent	Fair
Weather	Excellent	Excellent
Oxidation	Excellent	Good
Ozone	Excellent	Excellent
Radiation	Poor	Excellent
Water (cold)	Good	Good
Steam	Good	Good
Gas permeability	Good	Fair
Electricity	Excellent	Excellent

Table 4-8
Chemical Resistance General Guide for Selection of Gasket Material

Chemical	Description	Silicone	Ethylene Propylene Diene Modified
Acids	Dilute	Good	Good
	Concentrated	Poor	Good
Alcohols	Example: ethanol	Excellent	Excellent
Alkalis	Dilute	Suitability depends on conditions	Excellent
	Concentrated	Poor	Good
Halogenated solvents	Example: trichloroethylene	Suitability depends on conditions	Suitability depends on conditions
Aliphatic hydrocarbons	Examples: petrol, kerosene	Suitability depends on conditions	Poor
Aromatic hydrocarbons	Examples: benzene, toluene	Poor	Poor
Hydraulic oils	Silicate esters	Suitability depends on conditions	Suitability depends on conditions
	Phosphate esters	Suitability depends on conditions	Excellent
Ketones	Example: acetone	Suitability depends on conditions	Good
Mineral oil		Good	Poor
Synthetic lubricants (diesters)		Suitability depends on conditions	Poor

Table 4-9
Working Temperature Range, Physical Characteristics, and Fluid/Chemical Resistance Comparison of Silicone and Ethylene Propylene Diene Modified

Property	Silicone	Ethylene Propylene Diene Modified
Working temperature range	-70°C to 250°C	-50°C to 150°C
Physical characteristics:		
- Strength	Poor: 500–1000 lb.ft/in^2	Medium: 1500–2500 lb.ft/in^2
- Resilience	Medium: 40–60%	Medium: 40–60%
- Resistance to abrasion	Poor: +200 mm^3	110 mm^3
- Resistance to aging and weathering	Excellent	Good
Fluid/chemical resistance	Resistant to mineral oils and greases Not resistant to water, acids, and nonmineral automotive brake fluids	Resistant to nonmineral automotive brake fluid Resistant to “skydrol”-type phosphate ester fluid Resistant to water, steam, and many chemicals Not resistant to mineral oils and greases or hydrocarbon

Based on the physical characteristics data in Table 4-9, EPDM is stronger than silicone and is comparable in both resilience and resistance to abrasion, aging, and weathering. For the performance characteristics of the gasket, the maximum design temperature for the surface of items inside containment for this licensee is 300°F (149°C). The working temperature range of EPDM, as shown in Table 4-9, is -50°C to 150°C, which is less than that of silicone; however, it meets the maximum design temperature requirements for the surface of items inside the containment building.

For radiation, EPDM can withstand a radiation flux of 10^9 rads without any major changes; this topic is addressed in EPRI report *Radiation Data for Design and Qualification of Nuclear Plant Equipment* (NP-4172-M) [26]. Thus, it has excellent radiation resistance ability. In addition, for this licensee, both silicone rubber and EPDM have been qualified for harsh environment inside containment, so their sealing properties are not degraded in post-accident harsh environments. Also the licensee’s preventive maintenance program calls for an 18-month surveillance of this item—which further ensures that degradation will not occur without detection.

Based on the comparisons in the tables and the licensee’s contact with the supplier, both silicone rubber and EPDM are acceptable in sealing applications. For the purpose of sealing a post-accident containment environment from the outside atmosphere, both silicone rubber and EPDM are considered equivalent. Therefore, the EPDM rubber gasket is an equivalent replacement for the silicone rubber gasket.

4.5.6 Specification of Technical and Quality Requirements

The licensee specified the following technical and quality requirements in the procurement document:

- Technical requirements
  - Supplier mark number
  - Material composition
  - Drawing references for size and configuration
  - Shelf life requirements
  - Packaging and storage according to ANSI N45.2.2, Level B

  The licensee determined that there were no in-storage maintenance requirements for the gasket.
- Quality requirements
  - 10CFR50 Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Processing Plants"
  - 10CFR21, "Reporting of Defects and Noncompliance"
- Supplier documentation requirements
  - Certificate of Conformance to supplier drawing, material composition requirements, and QA program
  - Supplier drawings

4.5.7 Acceptance Requirements

The licensee identified the following acceptance requirements for the gasket:

- Supplier mark number verification
- Review of Certificate of Conformance
- Inspection of critical drawing dimensions
- Receipt of shelf life information

4.6 Timing Relay

Application:	Engineered safety feature actuation system equipment (10CFR50.49 not applicable)
Manufacturer:	Martrix
Identification No.:	7012PC
Supplier:	Not applicable
Identification No.:	

4.6.1 Need for a Technical Evaluation

The component identified by the original identification number is no longer available from the manufacturer, Martrix. The manufacturer has identified a replacement item, E7012PC002, which needs a technical evaluation to confirm that interface, interchangeability, safety, fit, and functional performance are not adversely affected.

4.6.2 Functional Classification of Components and Parts

This relay controls the delay in the application and removal of power to safety-related equipment. The function is to provide control and maintain circuit integrity. The relay is used to control safety-related equipment and is found in Class 1E circuits. Therefore, it is safety related. The control function is accomplished through a change of state of the relay contacts, so the functional mode of the relay is active.

4.6.3 Failure Modes and Effects Analysis

The credible failure mechanisms/modes and their effects on the timing relay are the following:

- Seizure or binding: Failure to change state or loss of control function
- Corrosion of contact surface: High resistance/loss of circuit integrity
- Short circuit or open circuit: Loss of circuit integrity
- Mounting integrity during seismic event: Loss of parent component integrity
- Contact chatter during seismic event: Spurious actuation

4.6.4 Like-for-Like or Alternate-Item Evaluation

The manufacturer has identified a replacement timing relay, and the original is no longer available. Therefore, this is an alternate-item procurement.

4.6.5 Equivalency Evaluation for Alternate Items

The critical characteristics for design are derived from the relay's function and the results of the FMEA as shown in Table 4-10.

Table 4-10
Critical Characteristics for Design

Function	Critical Characteristics for Design
Control	Operability of relay with time delay, insulation rating, pickup/dropout voltage, volt-ampere rating, and contact rating
Failure Mode/Mechanism	
Loss of circuit integrity; short circuit, open circuit, or contact chatter during seismic event	Circuit continuity/performance under load qualification to IEEE 344-1975
Seizure or binding of contacts	Same as those for control function
Corrosion of contact surface	Contact resistance/material
Mounting integrity during seismic event	Dimensions, weight, and mounting configuration

A comparison of these characteristics for the original and replacement relay is shown in Table 4-11.

Table 4-11
Comparison of Original and Replacement Timing Relays

Critical Characteristics for Design	Original	Replacement	Comparison
Seismic qualification	Seismic qualification performed on parent component	IEEE 344-1975	Reconciled by evaluation
Time delay	0.15–15 s	0.15–15 s	Identical
Contact configuration	2-DPDT	2-DPDT	Identical
Coil voltage	125 Vdc	125 Vdc	Identical
Weight	1.38 lb	2.13 lb	Reconciled by evaluation
Configuration mounting			Identical according to part drawing
Contact rating: - 110 Vdc - 120 Vac	 1.0 A 20.0 A	 1.0 A 10.0 A	Reconciled by evaluation
Voltage: - Pickup - Dropout	 80% rated pickup 10% rated dropout	 80% rated pickup 10% rated dropout	Identical
Insulation rating	500 MΩ minimum at 500 Vdc	500 MΩ minimum at 500 Vdc	Identical

The replacement relays have been built to withstand the radiation, temperature, and seismic environments in the auxiliary and control buildings of nuclear power plants. The replacement relay has been tested to show compliance with the requirements of IEEE 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," and IEEE 344-1975, "IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations." For this application, the IEEE 323-1974 qualification is not required because the relay being replaced is in a mild environment.

The replacement relay weighs up to 0.75 lb more than the original relay. This weight increase is insignificant in relation to the weight of the equipment in which the relay is installed. The mounting of the replacement relay is identical to that of the original relay. Thus, there is no significant impact on the seismic qualification of the parent component. The replacement relay has been tested to the requirements of IEEE 344-1975. The original relay was qualified as a part of the component using a seismic test procedure developed by the test laboratory. The replacement relay's seismic qualification is equal to or better than the original because the qualification parameters in the IEEE 344-1975 test report were found to be more stringent than those of the original.

No significant product change has been made, as shown in Table 4-11. The contact rating has been modified but has no effect because the rating is well within circuit load requirements. No impact on the control circuit operation will occur when the alternate timing relay is used to replace the original Martrix timing relay. Based on the comparison and qualification testing, the E7012PC002 relays are equivalent replacements for the original relays.

4.6.6 Specification of Technical and Quality Requirements

The licensee specified the following technical and quality requirements in the procurement document:

- Technical requirements
  - Part number and catalog description
  - Storage and packaging to ANSI N45.2.2, Level B requirements
  - Qualification to IEEE 344-1975

  The licensee determined that the relays had no shelf life or in-storage maintenance requirements.

- Quality requirements
  - 10CFR50 Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Processing Plants"
  - 10CFR21, "Reporting of Defects and Noncompliance"
- Supplier documentation requirements
  - Certification to qualification test report
  - Certificate of Conformance

4.6.7 Acceptance Requirements

The licensee identified the following acceptance requirements for the relay:

- Receipt inspection according to ANSI N45.2.2
- Post-installation test to verify time delay requirement
- Review Certificate of Conformance

4.7 Operational Amplifier

Application: Qualified safety parameter display system

Manufacturer: American Electronics
Identification No.: LM308AJ-8

Supplier: Federal Instrumentation
Identification No.: LM308AJ-8

4.7.1 Need for a Technical Evaluation

The operational amplifier, LM308AJ-8, is available from more than one manufacturer. The original amplifier was manufactured by American Electronics. The replacements are being procured from Rondex by the supplier, Federal Instrumentation. A technical evaluation is needed to procure the operational amplifiers from Federal Instrumentation.

4.7.2 Functional Classification of Components and Parts

The operational amplifier is used in the input filter board of the qualified safety parameter display system (QSPDS). The amplifier takes in an analog signal and provides a conditioned, filtered, analog signal out. The parent component's function is to provide this signal.

The operational amplifier is used for input circuit conditioning of Category 1 variables according to NRC RG 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plants and Environmental Conditions During and Following an Accident" [27]. Credible failure modes are ground, open circuit, and short circuit. The QSPDS is a redundant system based on RG 1.97 commitments. As part of its commitments under the requirements of RG 1.97, the licensee has elected to classify the QSPDS as safety related. Failure of the operational amplifier would not affect the integrity of the reactor coolant boundary, the capability to shut down the reactor and maintain it in a safe shutdown condition, and/or prevent or mitigate the consequences of accidents. However, the operational amplifier is a necessary component of the QSPDS, which has been classified as safety related. Based on this information, the functional classification is safety related.

4.7.3 Failure Modes and Effects Analysis

An FMEA would be complicated and unnecessary because of the similarities between the two items (see Section 4.7.5).

4.7.4 Like-for-Like or Alternate-Item Evaluation

At the time of procurement, it was unclear whether the replacement relay was physically different from the original. Therefore, for conservativism, this was considered an alternate-item procurement.

4.7.5 Equivalency Evaluation for Alternate Items

The critical characteristics for design of the original and replacement operational amplifiers were compared as shown in Table 4-12.

Table 4-12
Comparison of Original and Replacement Operational Amplifiers

Critical Characteristics for Design	Original	Replacement	Comparison
Manufacturer	American	Federal	Different; no effect
Identification	LM308AJ-8	LM308AJ-8	Identical
Part description	Operational amplifier	Operational amplifier	Identical
Mounting configuration	8 pin dip ceramic	8 pin dip ceramic	Identical
Temperature ratings	Minimum 0°C, maximum 70°C	Minimum 0°C, maximum 70°C	Identical
Radiation ratings	Negligible	Negligible	Identical
Power supply voltage	+18 Vdc	+18 Vdc	Identical
Input voltage	+15 Vdc	+15 Vdc	Identical
Supply current rating (Amps)	0.3 mA typical 0.8 mA maximum	0.3 mA typical 0.8 mA maximum	Identical
Required ANSI 45.2.2 packaging	B	B	Identical
Input bias current	1.5 mA typical 7.0 mA maximum	0.3 mA typical 0.8 mA maximum	Identical
Input offset current	0.2 mA typical 1.0 mA maximum	0.2 mA typical 1.0 mA maximum	Identical

Table 4-12 (continued)
Comparison of Original and Replacement Operational Amplifiers

Critical Characteristics for Design	Original	Replacement	Comparison
Common mode rejection ratio	96 db minimum 110 db maximum	96 db minimum 110 db maximum	Identical
Supply voltage rejection ratio	96 db minimum 110 db maximum	96 db minimum 110 db maximum	Identical
Input resistance	40 MΩ	40 MΩ	Identical
Input voltage range	±14 V	±14 V	Identical
Programmable	No	No	Identical
Input offset current (I_{IO})	1.0 mA	1.0 mA	Identical
Input bias current (I_{IB})	1.5 mA typical 7.0 mA maximum	1.5 mA typical 7.0 mA maximum	Identical
Large signal voltage gain	80 V/mV minimum 300 V/mV maximum	80 V/mV minimum 300 V/mV maximum	Identical
Input offset voltage	0.5 V	0.5 V	Identical

A review of the comparison shows no discernable differences because they are manufactured to the same specifications. This is a like-for-like procurement of an identical item, and procurement from Federal is acceptable as the form, fit, function, interface, and interchangeability requirements are not adversely affected.

4.7.6 Specification of Technical and Quality Requirements

The licensee specified the following technical and quality requirements in the procurement document:

- Technical requirements
  - Part number and catalog description
  - Specification of critical characteristics for design of mounting configuration, temperature rating, power supply voltage, input voltage, supply current rating, input bias current, and input offset current

  The licensee determined that the operational amplifier shelf life is five years, based on a study of discrete electronic components. The operational amplifier may be tested and recertified at expiration of the shelf life. No storage maintenance requirements were identified. Packaging and storage according to ANSI N45.2.2, Level B, have been determined to be adequate for discrete electronic components. No operational amplifiers were found on the excluded items lists.

- Quality requirements
  - Compliance to Federal Instrumentation QA program
  - Right of access for commercial-grade survey
  - Notification of changes in quality program requirements or catalog specification

  The licensee has surveyed the commercial quality program of Federal and found it to be adequate to control the critical characteristics for design of the operational amplifier.

  Note: The operational amplifier could also be purchased from the original supplier of the QSPDS, based on the supplier's approved 10CFR50 Appendix B program, which includes an adequate dedication procedure. In this scenario, the licensee would specify different quality requirements.

- Supplier documentation requirements

  The licensee requested certification to the catalog description, specific purchase order critical characteristics for design, and supplier quality program.

4.7.7 Acceptance Requirements

The licensee identified the following acceptance requirements for the operational amplifiers:

- Part number verification
- Physical comparison to catalog description
- Certificate of Conformance to commercial quality program
- Critical characteristics for design verification by a commercial-grade survey
- Loop calibration functional check

4.8 Limit Switch Lever Arm

Application: Limit switch for MSIVs

Manufacturer: Electrix Controls
Identification No.: EL060-53300

Supplier: Not applicable
Identification No.:

4.8.1 Need for a Technical Evaluation

Limit switch lever arm EL060-53300, as originally qualified, is no longer offered by the manufacturer for their Model EA-470 nuclear qualified limit switches. Lever arm EL060-53402 is a potential replacement for the original lever arm. To determine its suitability, a technical evaluation is required.

4.8.2 Functional Classification of Components and Parts

The limit switch lever arm actuates the limit switch cam for contact operation to provide indication of the MSIV position. The MSIV's function is to prevent uncontrolled blowdown from more than one steam generator. The MSIV isolates the non-safety-related portions from the safety-related portions of the main steam supply system. Movement of the lever arm is required to initiate a change of state for the limit switch to provide indication of the MSIV position. Therefore, the lever arm's function is to provide indication.

Failure of the limit switch lever arm could prevent correct indication of the MSIV position, thereby impeding the operator from following the course of an accident. Because the limit switch is used for indication, that failure would not prevent the MSIV from performing its safety-related function and will not affect the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a safe condition, and/or prevent an accident.

However, the MSIV indication provides an input signal to the post-accident monitoring system, thereby supporting a function required by RG 1.97, Category I commitments, and making it safety related. The limit switch in question is used in many other safety-related applications where indication is not considered safety related. The licensee decided for reasons of economics and ease of warehouse control to purchase all limit switch parts safety related.

4.8.3 Failure Modes and Effects Analysis

The failure mechanisms of the lever arm are fracture and seizure. The effect of either failure mode is loss of indication.

4.8.4 Like-for-Like or Alternate-Item Evaluation

The Electrix EL060-53300 lever arm assembly was part of the Electrix EA-470 limit switch when it was seismically qualified. The EL060-53300 lever is identical in material, length, and configuration to the EL060-53402 lever. However, there are differences in the roller diameter and thickness. Because the item has physically changed, this is an alternate-item procurement.

4.8.5 Technical Equivalency Evaluation for Alternate Items

Critical characteristics for design of the lever arm are material properties (for fracture and strength considerations), dimensions (for seizure and weight considerations), and tolerances. A comparison of these characteristics for the original and replacement limit switch lever arm is shown in Table 4-13.

Table 4-13
Comparison of Original and Replacement Limit Switch Lever Arm

Critical Characteristics for Design	Original	Replacement	Comparison
Lever arm thickness	0.5 in.	0.5 in.	Identical
Lever arm width:			Identical
- Spline end	0.62 in.	0.62 in.	
- Roller end	0.87 in.	0.87 in.	
Roller diameter	0.75 in.	0.87 in.	Reconciled by evaluation
Roller thickness	0.25 in.	0.27 in.	Reconciled by evaluation
Centerline roller to centerline roller	1.50 in.	1.50 in.	Identical
Tolerances	+0.01 in.	+0.01 in.	Identical

The limit switch is mounted on the MSIV. Because of the small changes in dimensions, the percentage of increased roller mass of the EL060-53402 compared to the EL060-53300—in relation to the mass of the switch—will not significantly increase the total mass of the switch/lever assembly nor will it affect the seismic capabilities of the limit switch. The seismic characteristics of the MSIV are also unchanged by this replacement lever arm. In addition, the change in roller diameter is resolved in the calibration setting of the limit switch. The increase in physical dimensions is small and does not affect the bounded technical requirements of the lever arm when assembled to the limit switch.

Based on this information, the replacement limit switch lever arm will satisfactorily perform its safety-related function and is an equivalent replacement.

4.8.6 Specification of Technical and Quality Requirements

The licensee specified the following technical and quality requirements in the procurement document:

- Technical requirements

  Part number, Electrix technical bulletin, and catalog description

- Quality requirements

  No special quality requirements invoked on supplier

- Supplier documentation requirements

  Part drawings with dimensions

4.8.7 Acceptance Requirements

The licensee identified the following acceptance requirements for the limit switch lever arm:

- Part number verification
- Verification of dimensions shown in Table 4-13

4.9 Relief Valve

Application: Emergency diesel cooling water systems

Manufacturer: Industrial Valves Co.
Identification No.: 2-1910H-1 (1-1-1-1)-XNC009

Supplier: Industrial Valves Co.
Identification No.: 2-1910H-1 (1-1-1-1)-XNC009

This example differs from other examples in that it represents the procurement for a component used in a safety-related application with a breakdown of parts and their associated functional classifications. The purpose of this comprehensive example is to illustrate an approach that is readily adaptable to a computerized database. By capturing these data in a retrievable format, repetitive evaluation on the same component or application(s) can be minimized.

4.9.1 Need for a Technical Evaluation

The valve Model No. 2-1910H-1 (1-1-1-1)-XNC009 has changed to Model No. 2-1910H-1 (1-1-1-1)-XLS. The licensee plans to procure the subject valve and the spare parts listed in Table 4-14 for inventory in the plant warehouse.

Table 4-14
Spare Parts List

Item No.	Item Description	Original Part No.	Replacement Part No.
1	Disk	0262522N	4664206N
2	Nozzle	0262814NC30090S462	0262814N
3	Disk retainer	24108022410182	2410802
4	Spindle assembly	0339812NC30090462	0339818N
5	Spindle retainer	24108092410109	2410809
6	Bonnet	44251030S462	4425103N
7	Bonnet gasket	3640103	3640503
8	Disk holder	0509210NC38890S462	4627006N
9	Guide	0338801	4667702
10	Guide gasket	3640103	3640502
11	Sealing wire	078579	8381203
12	Base	44360030S462	4436003N
13	Base stud	3232201N	3232201N
14	Base nut	2203304N	2203304N
15	Nameplate	4400801	4645101
16	Nameplate screws	2240282	2240282
17	Spring	0210VN	0210VN
18	Spring washer	0284915N	0284915N
19	Pipe plug	2140101	2131701N
20	Screwed cap	44269010S462	4426901N
21	Cap gasket	3680109	3620506
22	Adjustment screw	02632120S462	0263216N
23	Adjustment ring	460160100S09104	4628401
24	Adjustment ring pin	1076416	1076416
25	Adjustment ring pin gasket	3600605	3600605
26	Cap screw (gag plug)	3600605	3600605
27	Gag plug gasket	3600103	3600603

A technical evaluation is needed for the replacement valve and its parts to confirm that interface, interchangeability, safety, fit, and functional performance are not adversely affected.

4.9.2 Functional Classification of Components and Parts

The relief valve is used in the diesel cooling water system. It is installed in a mild environment, and its functions are to maintain pressure boundary and provide overpressure protection. Failure or malfunction of the relief valve could impact the required operation of the diesel generator. Based on this information, the relief valve performs safety-related functions, and its functional classification is safety related.

Mechanical movement of the valve internals is required to open the valve for overpressure protection. Relief valves are characterized as having an active function. Therefore, the functional mode is active.

A functional classification for the 27 spare parts in the relief valve is provided in Table 4-15. This is not intended to imply that parts classification is required in order to purchase the valve as a component. It is provided for illustrative purposes.

4.9.3 Failure Modes and Effects Analysis

The credible failure mechanisms/modes and their effects on the component are the following:

- Failure to open: Overpressure
- Fracture: Loss of cooling/pressure boundary
- Premature opening: Loss of cooling
- Failure to close: Loss of cooling
- Premature closing: Overpressure

Table 4-15 shows FMEA results for the parts contained in the relief valve.

4.9.4 Like-for-Like or Alternate-Item Evaluation

According to licensee contact with Industrial Valves Co., the replacement valve has a slight dimensional change to the seating area. Therefore, the replacement valve is not identical to the original valve, and this is an alternate-item procurement.

Table 4-15
Safety Classification Summary for 27 Spare Parts for 2-Inch Relief Valve

Item No.	Part's Description	Part's Function	Part's Failure Mechanism	Will Component Safety Function Be Affected Without the Part Under Consideration?	Will Part's Failure Mechanism Affect Component Safety Function?	Part's Functional Classification
1	Disk	Provide pressure boundary	Fracture	Yes, loss of pressure boundary	Yes, loss of pressure boundary	Safety related
2	Nozzle	Provide pressure boundary	Fracture	Yes, loss of pressure boundary	Yes, loss of pressure boundary	Safety related
3	Disk retainer	Keep disk in position	Fracture	Yes, loss of disk position	Yes, loss of disk position	Safety related
4	Spindle assembly	Provide actuation	Fracture	Yes, loss of actuation	Yes, loss of actuation	Safety related
5	Spindle retainer	Keep spindle assembly in position	Fracture	Yes, loss of spindle assembly position	Yes, loss of spindle assembly position	Safety related
6	Bonnet	Provide structural integrity and pressure boundary	Fracture	Yes, loss of pressure boundary	Yes, loss of pressure boundary	Safety related
7	Bonnet gasket	Provide seal	Fracture or corrosion	No, loss of seal only	No, loss of seal only	Non-safety related
8	Disk holder	Hold disk in position	Fracture	Yes, loss of disk position	Yes, loss of disk position	Safety related
9	Guide	Provide alignment	Fracture	Yes, loss of valve position	Yes, loss of valve position	Safety related
10	Gasket guide	Provide seal	Fracture or corrosion	No, loss of seal only	No, loss of seal only	Non-safety related
11	Sealing wire	Prevent adjustment tampering	Fracture	No, not required for the valve to perform its functions	No, the failure of lock wire does not affect the functions of the valve	Non-safety related
12	Base	Provide pressure boundary	Fracture	Yes, loss of pressure boundary	Yes, loss of pressure boundary	Safety related
13	Base stud	Connect base to bonnet	Fracture	Yes, loss of pressure boundary or actuation	Yes, loss of pressure boundary or actuation	Safety related

Table 4-15 (continued)
Safety Classification Summary for 27 Spare Parts for 2-Inch Relief Valve

Item No.	Part's Description	Part's Function	Part's Failure Mechanism	Will Component Safety Function Be Affected Without the Part Under Consideration?	Will Part's Failure Mechanism Affect Component Safety Function?	Part's Functional Classification
14	Base nut	Connect base to bonnet	Fracture	Yes, loss of pressure boundary or actuation	Yes, loss of pressure boundary or actuation	Safety related
15	Nameplate	Provide information	Fracture or corrosion	No, not required for the valve to perform its functions	No, not required for the valve to perform its functions	Non-safety related
16	Nameplate screws	Hold nameplate	Fracture	No, not required for the valve to perform its functions	No, not required for the valve to perform its functions	Non-safety related
17	Spring	Provide actuation	Fracture	Yes, loss of actuation	Yes, loss of actuation	Safety related
18	Spring washer	Locate spring	Fracture	Yes, loss of spring position	Yes, loss of spring position	Safety related
19	Pipe plug	Provide leadoff (for testing and maintenance)	Fracture	No effect on pressure boundary	No effect on pressure boundary	Non-safety related
20	Screwed cap	Cover adjustment parts	Fracture	No effect on pressure boundary	No effect on pressure boundary	Non-safety related
21	Cap gasket	Provide seals	Fracture or corrosion	No, not required for the valve to perform its functions	No, not required for the valve to perform its functions	Non-safety related
22	Adjustment screw	Provide spring adjustment	Fracture	Yes, loss of spring adjustment	Yes, loss of spring adjustment	Safety related
23	Adjustment ring	Provide blowdown adjustment	Fracture	Yes, will affect blowdown	Yes, will affect blowdown	Safety related
24	Adjustment ring pin	Provide ring adjustment	Fracture	Yes, loss of ring position	Yes, loss of ring position	Safety related
25	Adjustment ring pin gasket	Provide seal	Fracture or corrosion	No effect on seal or ring position	No effect on seal or ring position	Non-safety related

Table 4-15 (continued)
Safety Classification Summary for 27 Spare Parts for 2-Inch Relief Valve

Item No.	Part's Description	Part's Function	Part's Failure Mechanism	Will Component Safety Function Be Affected Without the Part Under Consideration?	Will Part's Failure Mechanism Affect Component Safety Function?	Part's Functional Classification
26	Gag screw (gag plug)	Provide seals (this item is for testing and maintenance)	Fracture	No, not required for the valve to perform its functions	No, not required for the valve to perform its functions	Non-safety related
27	Gag plug gasket	Provide seals	Fracture or corrosion	No, not required for the valve to perform its functions	No, not required for the valve to perform its functions	Non-safety related

4.9.5 Equivalency Evaluation for Alternate Items

The critical characteristics for design for the relief valve are shown in Table 4-16.

Table 4-16
Critical Characteristics for Design

Function	Critical Characteristics for Design
Maintain pressure boundary	Material, wall thickness, and pressure rating
Provide flow	Orifice dimension and inlet and outlet size
Relieve pressure	Relief range and spring rate
Failure Mechanism/Mode	
Fracture	Same as for pressure boundary
Failure to open	Calibration, operability, relief range, and spring rate
Premature opening	Calibration, relief range, and spring rate
Failure to close	Blowdown adjustment and spring rate
Premature closing	Calibration and relief range

As a minimum, the critical characteristics for design for each part are dimensions and material.

A comparison of the design parameters of the original and replacement valves is shown in Table 4-17. A summary of the changes between the spare parts of the original model and replacement model, with the justification of use, is provided in Table 4-18.

Table 4-17
Comparison of Original and Replacement Relief Valves

Design Parameters	Original	Replacement	Comparison
Code requirements	ASME Section III Class 3	ASME Section III Classes 2 and 3	Both designed for ASME Section III, Class 3
Orifice area	0.9127 in^2	0.9127 in^2	Identical
Weight	75 lb	80-lb maximum	Original was 75 lb. Industrial Valves Co. provides a new conservative weight estimate that shows maximum.*
Inlet flange	2 in. (Class 300)	2 in. (Class 300)	Identical
Outlet flange	3 in. (Class 150)	3 in. (Class 150)	Identical
Set pressure	200 psig	200 psig	Identical
Rated temperature	110°F	110°F	Identical
Stamped capacity	9432 lb/hr	344 gpm	The new model is rated for liquid service whereas the old model was for multiple-service use. These values are equivalent.
Center of gravity	X = +1/2 in. Y = 8-1/4 in.	X = +1/2 in. Y = 8-1/4 in.	Identical
Percent overpressure	10%	10%	Identical
Blowdown (psig)	10 psig	20 psig but is variable (see comments in next column)	According to licensee discussion with Industrial Valves Co., 10% overpressure, as related to set pressure, equals 20 psig. Blowdown adjustments are made by means of the adjusting ring; both models provided this feature. 10 psig for the old model was obtained from the NV-1 form.
Hydro test inlet: - Base - Nozzle - Disk	 350 psig 1100 psig 1100 psig	 350 psig 1100 psig 1100 psig	Identical

Table 4-17 (continued)
Comparison of Original and Replacement Relief Valves

Design Parameters	Original	Replacement	Comparison
Hydro test outlet: - Bonnet	350 psig	350 psig	Identical
Height	20-3/4 in.	21 in.	Original 20-3/4 in. is an approximate height. The maximum height is 21 in.
Other dimensions	Same	Same	Identical
Design pressure	200 psig	200 psig	Identical
Design temperature	110°F	110°F	Identical

* The weight difference, if any, does not pose a piping stress concern based on guidance provided in the EPRI report Guidelines for Piping System Reconciliation (NCIG-05, Revision 1) (NP-5639) [28].

Table 4-18
Summary of Changes for Original and Replacement Valve Spare Parts List

Item No.	Part's Description	Original Part Number	Replacement Part Number	Justification and Comments	Conclusions
1	Disk	0262522N	4664206N	Material changed from ASME SA182-F316 to ASME SA479 Type 316. This is a Code upgrade in bar stock material by Industrial Valves Co. Allowable stresses are the same; tensile and yield strengths are higher. The configurations are the same, and no other changes were made.	Fit and function are not affected; material change is equal to or better than original. Therefore, the replacement disk is an equivalent item.
2	Nozzle	0262814NC300908462	0262814N	The part number change is administrative. The original part number had NC300908462 on the end that represented a project-specific QA plan number used internally at Industrial Valves Co. The "N" at the end of 026814N designates the part as nuclear related. The two nozzles are identical.	The part number change is administrative. There is no change in part. Form, fit, and function are not affected. The item is identical. Therefore, this is a like-for-like procurement.
3	Disk retainer	24108022410182	2410802	Material changed from 17-7PH condition "A" stainless steel to Inconel 750 due to availability of material from industry standard upgrade. The Inconel 750 has better elongation, toughness properties, and corrosion resistance. The dimensions and configurations are the same, and no other changes were made.	Fit and function are not affected. Material change is equal to or better than original. Therefore, the replacement disk retainer is an equivalent item.
4	Spindle assembly: - Head - Stem - Pin	0339812NC30090462	 0339818N 0339717N 0338316N 2030387	The part number change is administrative. See the nozzle comments; both spindles are identical.	The part number change is administrative. There is no change in part. Form, fit, and function are not affected. The item is identical. Therefore, this is a like-for-like procurement.

Table 4-18 (continued)
Summary of Changes for Original and Replacement Valve Spare Parts List

Item No.	Part's Description	Original Part Number	Replacement Part Number	Justification and Comments	Conclusions
5	Spindle retainer	24108092410109	2410809	Same as disk retainer, only the material changed from 17-17PH condition "A" stainless steel to Inconel 750.	Fit and function are not affected. Material change is equal to or better than original. Therefore, the replacement spindle retainer is an equivalent item.
6	Bonnet	44251030S462	4425103N	Material changed from ASME SA216 Grade WCB to ASME SA216 Grade WCC, which has a lower carbon content. This is a standard change, and the yield and tensile strengths are the same. There are no other changes between the bonnets.	Fit and function are not affected. Material change is equal to or better than original. Therefore, the replacement bonnet is an equivalent item.
7	Bonnet gasket	3640103	3640503	Material changed from soft iron to Monel. The gaskets are solid Monel, zero compressibility, 0 ppm leachable chlorides/fluorides. This change occurred due to economic and shelf life/purity concerns. Monel is a nickel-rich alloy that has high strength ductility and excellent corrosion resistance. It is suitable for use in various applications. The dimensions and configuration are the same, and no other changes were made.	Fit and function are not affected. Material change is equal to or better than original. Therefore, the gaskets are equivalent replacements.
10	Gasket guide	3640103	3640502		
21	Cap gasket	3600109	3620506		
27	Gag plug gasket	3600103	3600603		
8	Disk holder	0509210NC38890S462	4627006N	Material changed from ASME SA182-F316 to ASME SA479 Type 316 SS. This is a Code upgrade in bar stock material by Industrial Valves Co. Allowable stresses are the same; tensile and yield strengths are higher. The outside diameter (OD) of 45° angle increased in the replacement model. This change permits adjustment of the ring above the nozzle seat needed for liquid services. There are no other changes.	Function is not affected. Material and OD are changed. These changes do not affect the functionality of the valve. The disk holder is equal to or better than original. Therefore, this is an equivalent replacement.

Table 4-18 (continued)
Summary of Changes for Original and Replacement Valve Spare Parts List

Item No.	Part's Description	Original Part Number	Replacement Part Number	Justification and Comments	Conclusions
9	Guide	0338801	4647702	Material changed from ASTM A479 Type 430 SS to ASTM A743 Grade CF8M. This change is standard from bar stock to casting. The material tensile strengths are the same, and ASTM A743 material is suitable for high temperature and corrosive service. There are no other changes for the replacement guide.	Fit and function are not affected. Material change is equal to or better than original. Therefore, the replacement guide is an equivalent item.
11	Sealing wire	078579	8381203	According to licensee discussion with Industrial Valves Co., the part number change is administrative only, and both sealing wires are identical.	The part number change is administrative. There is no change in part. Form, fit, and function are not affected. The item is identical. Therefore, this is a like-for-like procurement.
12	Base	44360030S462	4436003N	Material changed from ASME SA216 Grade WCB to ASME SA216 Grade WCC, which has a lower carbon content. This is a standard change, and the yield and tensile strengths are the same. There are no other changes between the original and the replacement.	Fit and function are not affected. Material change is equal to or better than original. Therefore, the replacement base is an equivalent item.
15	Nameplate	4400801	4645101	According to licensee discussion with Industrial Valves Co., the part number change is administrative only. Therefore, the nameplates are identical.	The part number change is administrative. There is no change in part. Form, fit, and function are not affected. The item is identical. Therefore, this is a like-for-like procurement.

Table 4-18 (continued)
Summary of Changes for Original and Replacement Valve Spare Parts List

Item No.	Part's Description	Original Part Number	Replacement Part Number	Justification and Comments	Conclusions
19	Pipe plug	2140101	2131701N	Material changed from ASTM A182 Grade F304 SS to ASTM A479 Type 316 SS. This is an upgrade in bar stock material by Industrial Valves Co. The dimensions and configuration are the same, and there are no other changes between the pipe plugs.	Fit and function are not affected. Material change is equal to or better than original. Therefore, the replacement pipe plug is an equivalent item.
20	Screwed cap	44269010S462	4426901N	The part number change is administrative according to licensee discussion with Industrial Valves Co.; therefore, the items are identical.	The part number change is administrative. There is no change in part. Form, fit, and function are not affected. The item is identical. Therefore, this is a like-for-like procurement
22	Adjustment screw	02632120S462	0263216N	According to licensee discussion with Industrial Valves Co., the part number change is administrative only, and both adjustment screws are identical.	The part number change is administrative. There is no change in part. Form, fit, and function are not affected. The item is identical. Therefore, this is a like-for-like procurement.

Table 4-18 (continued)
Summary of Changes for Original and Replacement Valve Spare Parts List

Item No.	Part's Description	Original Part Number	Replacement Part Number	Justification and Comments	Conclusions
23	Adjustment ring	460160100S09104	4628401	The material changed from ASTM A351 Grade CF8M to ASTM A479 Type 316 SS. According to licensee conversation with Industrial Valves Co., this is a low-volume item that is typically made from bar stock. The OD of the ring was decreased and the profile changed. The ring description changed from 1900H to 1910H-XLS.	Function is not affected; material and OD are changed. These changes do not affect the functionality of the valve. The item is equal to or better than original. Therefore, this is an equivalent replacement.
N/A	Drive screw (self tapping)	07577202	None	In the original model, this screw was on the outside of the bonnet to wire the cap. In the new model, a hole is drilled in the corner of the bonnet, and the cap can be wired to the two nuts. Therefore, the self-tapping screw has been removed from the new model.	This modification does not affect the valve functionality. Therefore, this is an acceptable modification.

Based on the comparison in Table 4-17, a summary of the changes in Table 4-18, licensee conversation with the manufacturer, and a letter from Industrial Valves Co., it is concluded that the two valves are equivalent with the exception of a slight dimensional change to the seating area (see Figures 4-1 and 4-2). The new model has the same performance characteristics as the old model.

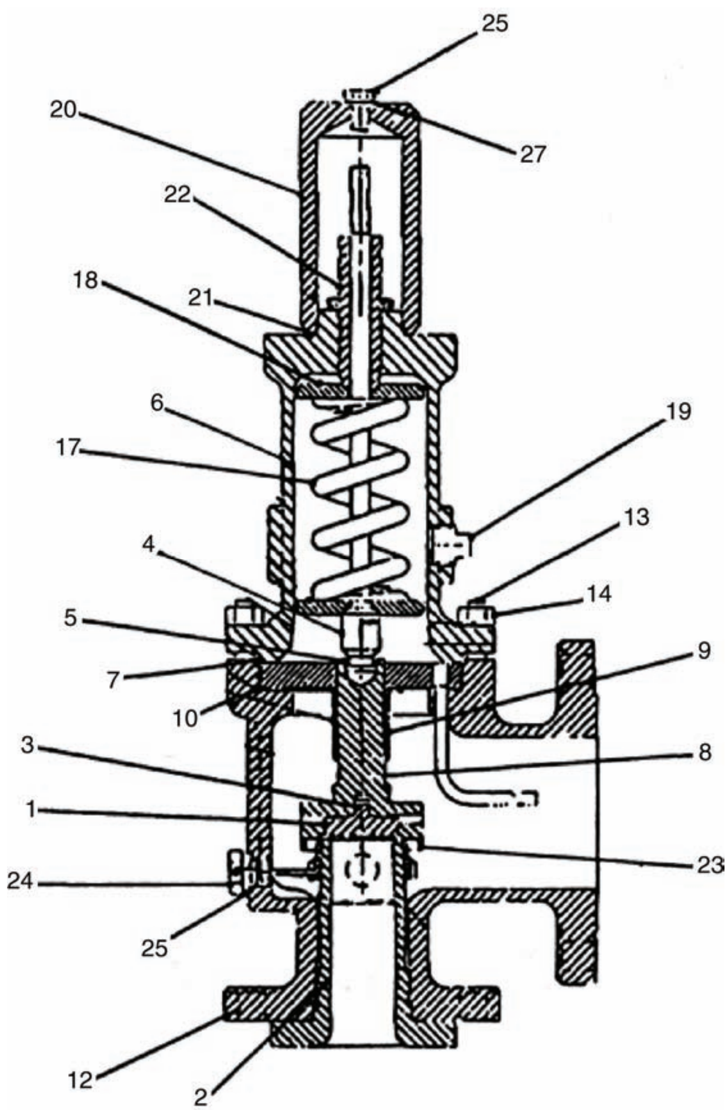

Figure 4-1
Relief Valve

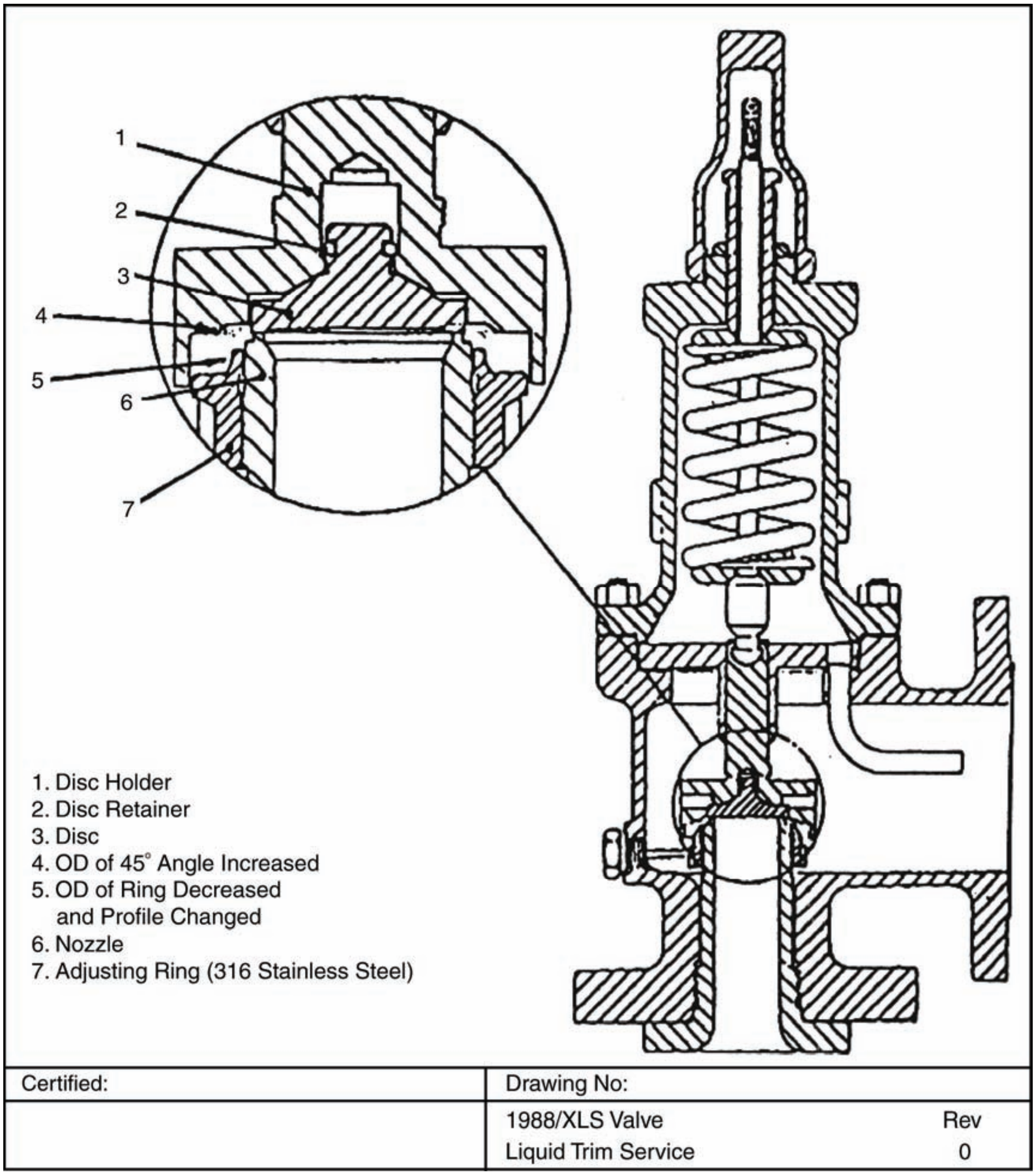

Figure 4-2
Relief Valve Detail

The replacement parts are identical or equivalent to the original parts for this application. According to licensee discussions with Industrial Valves Co., the old and new parts are interchangeable; however, if the new adjusting ring is used in the old model, it cannot be adjusted as high as in the new model. This has no effect on setting ranges in this application.

Based on this evaluation, the use of the new model or parts would not impact the operation of the diesel generator cooling water system. Therefore, the valve and its parts are equivalent replacements.

4.9.6 Specification of Technical and Quality Requirements

The licensee specified the following technical and quality requirements in the procurement document for the relief valve:

- Technical requirements
  - Valve model and description
  - ASME Code reference (Code year and addenda)
  - Certified design specification
- Quality requirements
  - ASME NCA-3800, "Quality Program Requirements"
  - 10CFR21, "Reporting of Defects and Noncompliance"
  - ASME "N" Certificate of Authorization Holder
- Supplier documentation requirements
  - ASME Code Data Reports
  - Certificate of Conformance

The technical and quality requirements for each of the 27 parts should be developed individually from their pertinent data.

4.9.7 Acceptance Requirements

The licensee identified the following acceptance requirements for the valve:

- Review of ASME Code Data Report
- Review of Certificate of Conformance
- Calibration verification prior to installation

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A
LISTING OF TYPICAL COMPONENT FUNCTIONS

Typical Component Functions	
Component Function	**Description**
To maintain pressure integrity	Mechanical function. Pressure integrity is required to prevent the escape or entry of an unacceptable leakage rate or quantity of fluid past the pressure boundary. It applies to both active and passive equipment, inclusive of the item that contains a fluid.
To open	Mechanical function. Active components are normally closed and are required to perform a mechanical movement to achieve and maintain an open position, thereby allowing the minimum design flow.
To remain open	Mechanical function. Passive components are normally open and are required to maintain an open position, allowing the minimum design flow.
To close and to isolate	Mechanical function. Active components are normally open and are required to perform a mechanical movement to achieve and maintain a closed position, thereby stopping process flow. (Absolute sealing is not considered part of this function.)
To remain closed and to isolate	Mechanical function. Passive components are normally closed and are required to maintain a closed position, thereby stopping process flow. (Absolute sealing is not considered part of this function.)
To provide directional control	Mechanical function. Active and passive components are required to govern the direction of process fluid or gas movement, which is determined by the operating parameters of the system.
To activate or modulate	Mechanical function. Active components are required to perform continuing mechanical movement (for example, a component that modulates the position in order to regulate flow).
To maintain structural integrity	Mechanical function. Active and passive components are required to maintain their structural form. Component does not collapse, disassemble, or disintegrate. Failure of a part confined internally to the component does not constitute a violation of structural integrity.
To provide pressure and flow	Mechanical function. Active components are required to provide minimum design pressure/flow of process fluid or gas through component movement.
To provide containment isolation	Mechanical function. Active or passive components are required to be closed for containment isolation (not to be used as a replacement of component function to close and to isolate).
To provide combustible gas control	Mechanical function. Combustible gas control is required in order to prevent the buildup of volatile fluids within containment.

Typical Component Functions	
Component Function	**Description**
To blend	Mechanical function. This applies to blenders or mixers that combine ingredients or chemicals by mixing.
To provide support and to secure	Mechanical function. This is required in order to restrict movement or provide damping to ensure dynamic stability.
To maintain circuit integrity	Electrical function. Maintain intact electrical state such that design current flow is accomplished through the component and that excess current flow—caused by shorting—does not occur. Components that must distribute or allow rated current flow include buses, distribution panels, fuses, and circuit breakers. This function applies to all electrical components to prevent excess current flow and shorts.
To maintain electrical isolation	Electrical function. Applies to those components that prevent excess current flow, usually caused by short circuit, from propagating through the circuit and impeding the operation of other components. Components with this function are typically used to isolate non-Class 1E circuit failures from Class 1E circuits.
To change state	Electrical function. Changes state to perform a control function. State changes include normally energized to deenergized and normally deenergized to energized state. Modulate between these states. Examples of devices that change state in order to function include relays, circuit breakers, and solenoid-operated valves.
To transform or supply energy	Electrical function. This applies to those components required to provide voltage/current to appropriate power levels for use by other components.
To provide signal	Electrical function. This applies to components that generate or transmit a process signal used for control or indication purposes. It applies to transmitters, elements, and signal conditioners.
To provide control	Electrical function. This applies to those components whose primary function is to control other components. This function is typically accomplished through a change in contact position(s) and applies to switches.
To provide filtering	Mechanical or electrical function. Passive components are required to remove particles or debris from process fluid or gas.
To provide motive force	Mechanical or electrical function. Active components are required to provide motive force, to start and commence a performance or an operation, and to continue such operation as required.
To provide heat control	Mechanical or electrical function. This relates to the process of heating or cooling a fluid, gas, or other component. Mechanically, this function is typically accomplished by a heat exchanger or cooling coil. Electrically, this function is accomplished by an electrical heater.
To provide indication	Mechanical or electrical function. This is required to provide indication, either local or remote, to operations or maintenance personnel.

B
TYPICAL FAILURE MECHANISMS/MODES

Term	Definition
Fracture	Separation of a solid accompanied by little or no macroscopic plastic deformation.
Corrosion	The gradual deterioration of a material due to chemical or electromechanical reaction, such as oxidation, between the material and its environment.
Erosion	Destruction of materials by the abrasive action of moving fluids, usually accelerated by the presence of solid particles carried with the fluid.
Open circuit	An electrical circuit that is unintentionally broken so that there is no complete path for current flow.
Short circuit	An abnormal connection by which an electric current is connected to the earth or to some conducting body, usually resulting in excessive current flow.
Blockage	Clogging of a filtering medium, resulting in the inability to perform its purification function or blockage of flow.
Seizure	Binding of a normally moving item through excessive pressure, temperature, friction, or jamming.
Unacceptable vibration	Mechanical oscillations produced that are beyond the defined permissible limits due to unbalancing, poor support, or rotating at critical speeds.
Loss of properties	A loss of mechanical and physical properties of a material due to exposure to high temperature or to radiation.
Excess strain	Under the action of excessive external forces, the material of the part becomes deformed or distorted.
Mechanical creep	From prolonged exposure to high temperature and stress, the object shows a slow change in its physical (shape and dimension) and mechanical characteristics.
Ductile fracture	Fracture characterized by tearing of metal accomplished by appreciable gross plastic deformation.

C
LISTING OF TYPICAL CRITICAL CHARACTERISTICS FOR DESIGN

Physical Characteristics		
Amperage	Fatigue resistance	Polarity
Balance	Flammability	Pour point
Capacitance	Flash point	Purity
Chemical content	General configuration or shape	Resilience
Cloud point	Homogeneity (of material)	Resistance
Coating	Impedance	Shear strength
Composite metal hardness	Inductance	Solubility
Concentration	Leachable halogen content	Spring constant
Conductivity	Load rating	Surface finish
Continuity	Luminescence	Surface hardness
Density/specific gravity	Material of construction	Tensile strength
Dielectric strength	Melting point	Thermal conductivity
Dimensions (to within manufacturer's tolerance)	Mounting	Torque
Drop point	NIL-ductility temperature	Viscosity
Ductility	Oil/water separation	Wall thickness
Durometer hardness	Permeability	Weight
Elasticity	Plating	

Performance Characteristics		
Accuracy	Input/output voltage	Pressure rating
Bias current	Interrupt rating	Radiation rating
Burn-in endurance	Interrupting current	Relief range
Calibration	Leakage	Repeatability
Chatter	Load rating	Runout
Current rating	Open/closure time	Rotational direction
Cycle time	Operability (fail, open/close, stroke)	Set-point stability (no drift)
Deadband width	Operating range	Speed
Filter rating	Performance during under-voltage conditions	Temperature rating
Flow rate	Pickup/dropout voltage	Time/current response
Gain	Power rating	Voltage rating
Horsepower	Pressure drop	

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