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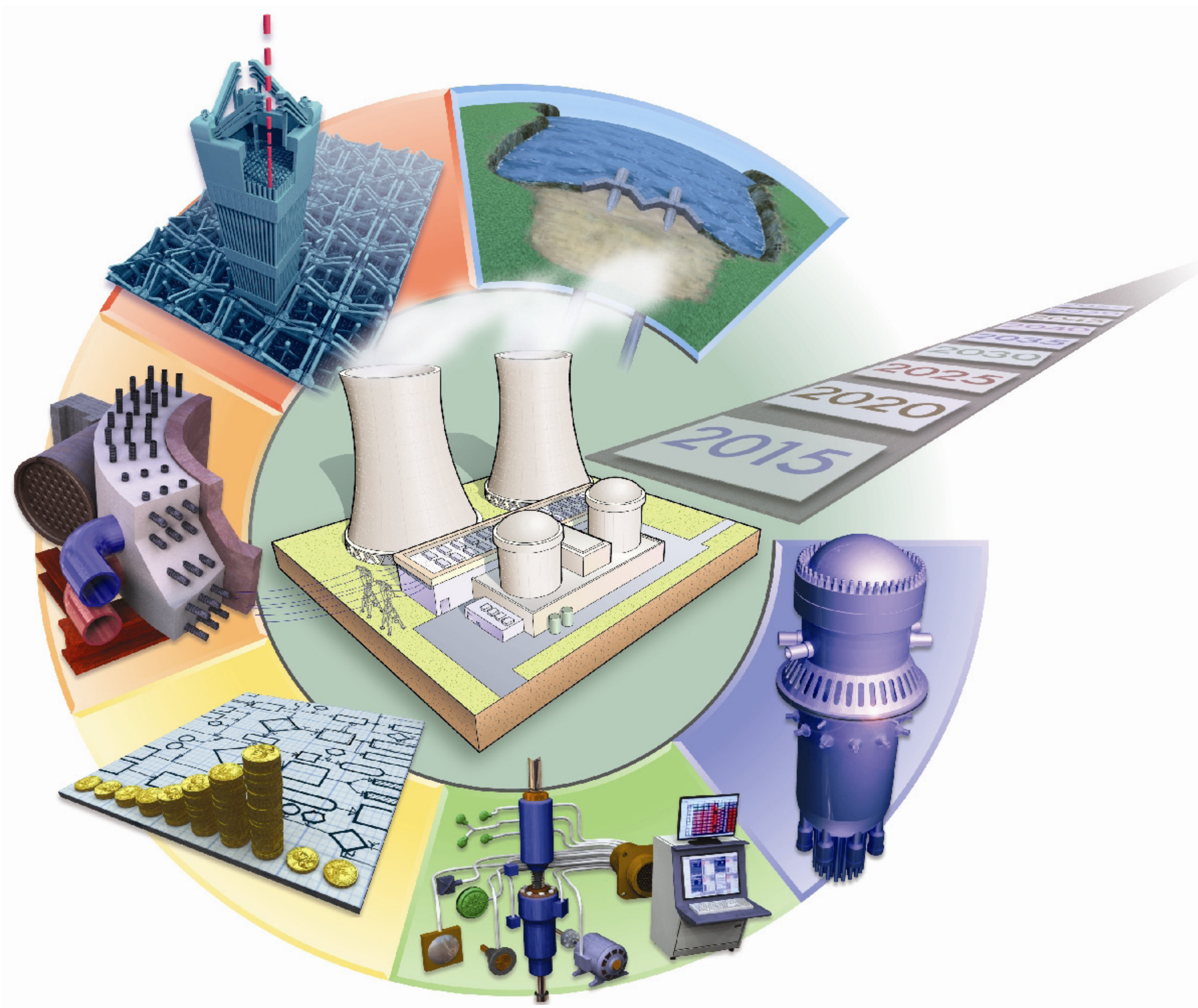
Plant Support Engineering: Critical Spares

Program Development



Plant Support Engineering: Critical Spares

Program Development

1019162

Final Report, December 2009

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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: Critical Spares—Program Development. EPRI, Palo Alto, CA: 2009. 1019162.

PRODUCT DESCRIPTION

The purpose of this report is to build upon the information included in Electric Power Research Institute (EPRI) report 1011861, *Considerations for Developing a Critical Parts Program at a Nuclear Power Plant*, and to facilitate efforts to enhance or promote consistency in existing critical spares programs. Many EPRI members have implemented critical spares programs using various approaches. This project involves the benchmarking of mature critical spares programs to summarize their organizational structure, basic approach, and processes as well as best practices, precautions, and lessons learned. A basic flowchart and description of a critical spares process are also included.

Results and Findings

One aspect of implementing an equipment reliability program focuses on identification of equipment that is critical to plant operations, including safety-related and non-safety-related equipment, so that plant operations and maintenance can focus on activities required to support critical equipment. Once equipment is identified as critical, it is imperative that the items necessary to support maintenance and operation of the equipment are available. The results of this report strongly suggest that there are many different ways to identify critical spare items (parts and components). These methods are primarily based on available resources and experience at each particular utility.

Challenges and Objectives

In addition to building upon the information included in EPRI report 1011861, this report provides a generic process for identification of critical spare items that can be tailored to meet the needs of commercial nuclear power industry facilities. This report also provides two examples of mature critical spares programs to supplement the detailed implementation process for establishing a critical spares program.

Applications, Value, and Use

The guidance contained in this report will help licensees to define a critical spare at their facilities, develop a program that identifies those critical items required to support critical plant equipment, and ensure that these spares are available to support plant operations.

EPRI Perspective

The methodology contained in this report represents a significant collection of information, including techniques and good practices, related to the identification, categorization, and supply of critical replacement parts integral to addressing critical equipment and critical spare parts programs. This compiled information provides a single point of reference for plant work planning and supply chain personnel. Through the use of this report in close conjunction with the industry guidance provided, EPRI members should be able to significantly improve and consistently implement the processes associated with identifying and categorizing parts within critical equipment and making them available when they are needed. This will subsequently help to increase the reliability and availability of the critical components on which work activities are performed.

Approach

A technical advisory group (TAG) was formed that consisted of licensee representatives from EPRI Plant Support Engineering utility members. Input was solicited regarding current practices for categorizing parts within critical components, identifying critical part demands and how each licensee's respective supply chain organization ensured that those demands were met. The group of individuals in this TAG included members who actively participate in the Equipment Reliability Working Group. The effort included benchmarking experience-proven practices and techniques from two utility critical spares programs and implementation efforts.

Keywords

Component classification
Component identification
Critical component
Critical spare
Equipment reliability
Replacement item
Required part

ACKNOWLEDGMENTS

EPRI thanks the following individuals who made significant contributions to the development of this report. Their valuable insight and experience were essential in the successful completion of this project.

Ujjal Mondal	CANDU Owners Group Inc.
Sherri Kennedy	Constellation Energy Nuclear Group
Tim Rogers	Constellation Energy Nuclear Group
Jim Read	Constellation Energy Nuclear Group
Jim Grant	Duke Energy Corporation
Kevin Matthews	Duke Energy Corporation
Jerry Kernaghan	Electric Power Research Institute
Marc Tannenbaum	Electric Power Research Institute
Penny Wood	Exelon
Dan Philipps	FirstEnergy Corporation
Paul Von Hatten	Ontario Power Generation
Christina Myers	Ontario Power Generation
Michael Tulay	Sequoia Consulting Group, Inc.
John Nesbitt	South Carolina Electric and Gas

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EXECUTIVE SUMMARY AND INTRODUCTION

1.1 Introduction

Many licensees have identified critical equipment. To enable adequate support of critical equipment, the availability of spare and replacement items must also be ensured. These spare and replacement items or critical spares may include replacements at the equipment level (such as a globe valve), part-level items (such as disk, stem, and seat), and consumables (such as gaskets, packing, and lubricants) necessary to support maintenance activities and contingency plans associated with critical equipment.

In many cases, equipment classified as critical comprises engineered items that require a very long lead time to procure. In addition, these items and their replacement parts are typically high-cost items. Identifying appropriate spare and replacement items and subsequently determining which ones should be maintained in inventory and the quantities in which they should be stocked present a challenge. Availability of parts to address every conceivable contingency plan must be balanced against the associated increases in inventory valuation and carrying costs.

Members of the Electric Power Research Institute (EPRI) have implemented critical spares programs using various approaches. This project involves the benchmarking of mature critical spares programs to summarize their organizational structure, basic approach, and processes, as well as best practices, precautions, and lessons learned. A basic flowchart and description of a critical spares process are also included.

This report builds upon information in EPRI report 1011861, *Considerations for Developing a Critical Parts Program at a Nuclear Power Plant* [1], and should facilitate efforts to enhance or promote consistency in existing critical spares programs.

1.2 Purpose and Scope

1.2.1 Purpose

The purpose of this report is to provide guidance that can be used to implement or improve critical spares programs with increased efficiency. At this time, many EPRI members have implemented critical spares programs using various approaches. This project involves the benchmarking of mature critical spares programs to summarize their organizational structure, basic approach, and processes, as well as best practices, precautions, and lessons learned. A basic flowchart and description of a critical spares process are also included.

1.2.2 Scope

Figure 1-1 illustrates the scope and contents of this report.

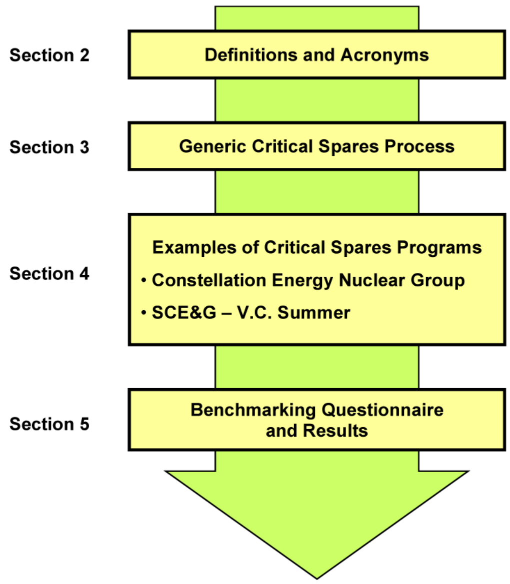


Figure 1-1
Scope of report contents

Section 2 is provided to familiarize the reader with common terminology and acronyms associated with developing and implementing a critical spares program. Section 3 presents a detailed process diagram describing key elements of the critical spares program, as well as implementation guidance for each step. Section 4 provides two illustrative examples of how a critical spares program was effectively implemented at a nuclear utility. The first example presents an established program developed for a fleet utility, Constellation Energy Nuclear Group. The second example presents a mature program developed for a single-unit utility, South Carolina Electric and Gas (SCE&G). Section 5 summarizes the approach used to benchmark the two utility programs described in Section 4 and concludes with the results obtained through the benchmarking questionnaire. A complete listing of appropriate references is provided in Section 6.

1.3 Background

1.3.1 Implementation of an Equipment Reliability Program

In recent years the commercial nuclear generation industry has focused on identification of equipment that is critical to plant operations, including safety-related and non-safety-related equipment, so that plant operations and maintenance departments can focus on activities required to support critical equipment. Classification of critical equipment helps licensees ensure that equipment reliability (ER) is adequately addressed in accordance with the requirements of the

Nuclear Regulatory Commission's 10CFR50.65 (the "Maintenance Rule"), Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants [2]. Classification of critical equipment allows the utility to focus resources on the pieces of equipment that are most essential to safety, reliability, and generation.

As shown in Figure 1-2, EPRI has published the following reports related to classification of equipment and the subsequent identification of critical items consistent with the *Equipment Reliability Process Description, INPO AP-913* (INPO is the Institute of Nuclear Power Operations) [3].[1]

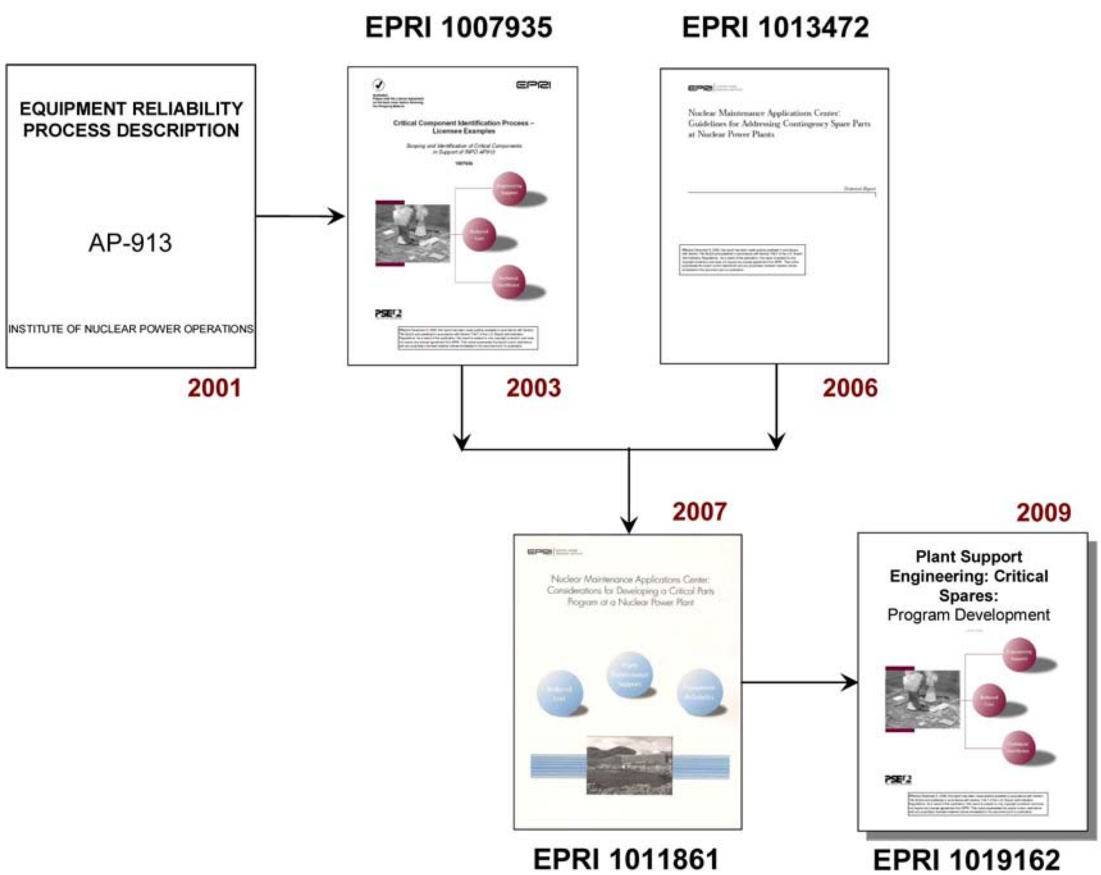


Figure 1-2
EPRI reports related to categorization of equipment and parts

As shown in Figure 1-2, in 2003, EPRI published report 1007935, *Critical Component Identification Process—Licensee Examples: Scoping and Identification of Critical Components in Support of INPO AP-913* [4]. This report provides utility examples of how the maintenance rule could be effectively implemented and equipment subsequently categorized.

[1] Access to INPO reports and materials is restricted to organizations authorized by INPO. The information is confidential and for the sole use of the authorized organization.

Though not directly related to implementation of the maintenance rule, in 2006, the EPRI Nuclear Maintenance Applications Center (NMAC) published report 1013472, *Guidelines for Addressing Contingency Spare Parts at Nuclear Power Plants* [5]. The primary purpose of this report is to look at the planning of spare parts from a demand perspective and provide guidance to licensees regarding which items are truly required for maintenance activities and which items should be available for contingencies.

In 2007, EPRI NMAC published report 1011861, *Considerations for Developing a Critical Parts Program at a Nuclear Power Plant* [1]. This report considers the guidance from 1013472, which looked at spare parts from the demand perspective, and then further develops the concept of a critical spare from both the demand and supply perspectives. The objectives of EPRI 1011861 are as follows:

- Provide guidance to licensees with respect to identification of critical parts required to support plant operations.
- Establish a clear definition of the meaning "critical" as it relates to replacement items.
- Develop a systematic approach to the subject based on needs and risk.
- Provide factors for consideration to optimize inventory values, while at the same time providing sufficient parts to operate and maintain the plant.
- Provide a documented basis for the value of a significant portion of most nuclear plant inventory.
- Provide industry best practices and lessons learned.
- Provide guidance regarding the treatment (that is, specification, purchasing, acceptance, storage, materials management, work planning, and so forth) of critical components and parts.

1.3.2 Determination of Items Required to Support Critical Plant Equipment

Once critical equipment has been identified and maintenance plans have been developed, resources must be allocated to permit execution of the work. A key to execution of planned and unplanned maintenance is the availability of spare and replacement parts. Just as equipment can be classified as critical or noncritical, the bill of materials or parts list for a specific piece of equipment can be evaluated to determine which parts and or materials should be classified as critical (to the maintenance plans) and which could be classified as noncritical. Personnel with hands-on experience maintaining and monitoring the condition of the equipment are best qualified to perform the critical parts determination.

In addition to determining which part-level items are critical, an evaluation should also be performed to determine if it is appropriate to maintain an equipment-level spare (such as a whole valve) in inventory. This evaluation should be based in part on maintenance philosophy, the number of applications in the plant, a repair versus replace analysis, and so forth.

The list of critical parts along with the spare equipment-level item (if applicable) compose the set of critical spares required to support the critical equipment.

1.3.3 Setting up Critical Spare Items for Transactions

When the set of critical spares has been identified, the list of items needs to be checked against existing inventoried items (stock codes, catalog identifications [IDs], materials codes, and so forth) to determine if each critical part is currently established for transactional purposes in the plant information system.

After all critical spares have been set up in the plant information system, the following activities may need to be performed (if not previously completed):

- Determine the safety classification and procurement quality classification of the item.
- Determine whether the critical spare will need to be procured and placed in inventory.
- Establish the method of procuring the items, when appropriate.
- Establish reorder parameters (such as reorder point, reorder quantity, minimum/maximum).
- Establish applicable enhanced procurement measures to verify acceptability of the item for service before placing it into inventory (typically enhanced source or receipt inspection).

The reader of this report should recognize the following key points regarding the identification of a critical spare:

> **Not all parts listed on an equipment bill of materials (BOM) need to be spares in inventory.**
>
> **Just because a part is categorized as critical does not mean the licensee needs to stock it in inventory, but a plan should exist to make it available when it is needed.**

1.3.4 When Is a Spare a Critical Spare?

In the context of this report, replacement items determined to be critical to supporting the operation and maintenance of critical equipment are called “critical spares.” As described, both part- and equipment-level items can be identified as critical spares.

The criteria used to determine if a spare is a critical spare may vary with the organization, because this determination will depend on the organization’s maintenance strategy, repair-versus-replace policies, risk tolerance, and inventory management policies.

1.3.5 Definition of a Critical Spare

Developing an industry-standard definition for the term “critical spare” has proven to be challenging. As suggested in Section 1.3.4, the definition of a critical spare may vary for different organizations based upon their maintenance philosophy, risk tolerance, and maintenance policies.

Members of the Equipment Reliability Working Group (ERWG) have suggested the following generic definition for a critical spare.

> A critical spare can be defined as a component or part needed to return critical components to service following normal and reasonably anticipated wear and tear, including credible failures that would not normally be predicted via monitoring and trending programs with sufficient advance warning to allow for procurement activities and reasonable lead times for the needed replacement items.

The working definitions employed by the programs benchmarked during development of this report are included in Section 2.

The definition can be expanded upon or supported by a tool such as a description of the issues critical spares are expected to address or a decision flowchart that is tailored to accommodate an organization's maintenance policies.

As an example, Constellation Energy describes its Critical Component Stocking List as a list that includes all "Replacement Parts" whose failure would prevent the component from performing its critical functions and those parts necessary to replace them. This is a more comprehensive list than the normal list of preventive or normal maintenance wear parts, but it does not include all the parts of the component. For instance, even though valve bonnets may be "replaceable," they are not typically stocked as critical spares. However, this list does include parts that have quite low failure rate probability. The basic approach is to identify items that have an estimated failure probability of up to once per 10–20 years or less than the duration of the preventive maintenance (PM) activities that will replace the part. The probability threshold will be need to be established based on the organization's business model.

1.3.6 Benchmarking

Benchmarking established critical spares programs was an important part of the research involved in preparing this report. Summaries of the programs that were benchmarked are included in Section 4.

The technical advisory group (TAG) benchmarked the critical spares program at SCANA's V. C. Summer Nuclear Station (VCS) and Constellation Energy's fleet critical spares program at the Calvert Cliffs Nuclear Power Plant.

The types of information included in Section 4 include the following:

- Brief overviews of each organization's programs
- How the projects were resourced
- Key program implementation challenges
- Important features of each program

A table summarizing answers provided by each station to a standard set of benchmarking questions is included in Section 5.

1.4 Challenges Associated with Implementing an Effective Critical Spares Program

1.4.1 Definition of a Critical Spare That Meets Your Needs

As will be described in Section 2.1 of this report, different organizations have developed different definitions for the term “critical spare.” It is important to develop a clearly understood definition of the term so that the individual program can be designed accordingly. Existing related processes; procedures; and programs such as procured item quality, PM, and obsolescence programs may influence how the term is defined within an organization.

1.4.2 Screening Process for Identification of Critical Spares

Most plants have identified critical equipment. Once equipment has been identified as critical, it follows that the spare and replacement items critical to supporting the operations and maintenance of the critical equipment must be identified. A graded approach can be applied focusing initially on the highest risk inventory, typically inventory with a low failure probability and a high failure consequence. The industry has defined high critical component failures in the ERWG guidance report, *Industry Equipment Reliability Index Estimator,* Table A: High Critical Component Failures.

Identification of these critical spares can be addressed on a project basis or can be added to the responsibilities of existing staff as incremental workload. Regardless of the approach, cooperation and expertise from several plant organizations will be necessary. Expertise from maintenance, system engineering, and supply chain will be required to successfully identify critical spares and establish appropriate inventory-stocking levels and reorder parameters. One organization should have overall responsibility for and ownership of the process.

Another consideration is assignment of critical spares in the plant enterprise asset management system. Critical spares will have to be assigned stock codes (catalog IDs, material numbers, and so forth) and clearly identified as critical spares on panels or screens in the system so that responsible individuals know how to handle transactions (reservations, issues, receipts, put-away, reorders, and so forth) for those items accordingly.

1.4.3 Control of Inventory Growth

Stocking policies to address high-consequence, low-probability failures result in larger quantities of items in stock and are typically applied for items identified as critical spares. This can significantly increase inventory in two ways. First, long-lead time or high-cost engineered items previously not carried in inventory are typically added as stocked items. Second, the reorder parameters for items already carried in inventory are typically adjusted to be more conservative when these items are identified as critical, resulting in higher inventory levels and valuation.

These policies have the potential to add significant expense and even to affect compliance with regulations such as Sarbanes-Oxley [6], which applies to publicly held corporations and typically results in measures to ensure that inventory is necessary, correctly valued, and reflected in the value of the corporation. The Sarbanes-Oxley Act (commonly referred to as SOX) refers to The Public Reform and Investor Protection Act signed into law on July 30, 2002. This act is intended protect investors in publicly owned companies by improving the accuracy and reliability of corporate disclosures made pursuant to the securities laws, among other purposes.

Because the value of inventory plays an important part in accounting for the cost of operating a plant, processes used to control inventory may be examined to ensure compliance with SOX requirements. Unnecessary inventory can lead to inadvertent overvaluation of a company, and may lead in extreme situations to noncompliance with federal regulations.

At least one utility materials manager commented that they experienced enormous growth (almost $10 million in little more than a year) in inventory because of a critical spares program that was implemented without controls designed to limit inventory growth.

1.4.4 Translating Risk Tolerance into Programmatic Action

Program owners must understand their tolerance for risk. Being overly conservative could result in rapidly increasing inventory valuation, but being nonconservative could lead to unavailability of critical spares when they are required to support planned or unplanned maintenance activities. Owners should involve subject matter experts from all key organizations such as maintenance, system engineering, and supply chain when establishing criteria for determining when an item is a critical spare and when establishing stocking policies.

1.4.5 Availability of Resources

The individuals best suited to analyze equipment and determine which items are critical spares are often not available to do so. As a result, individuals with less pertinent experience may be called upon to make the determination. This can result in overly conservative decisions, an enormous population of items identified as critical spares, unnecessary inventory growth, and the resulting dilution of true priorities and resources to the point where it is not possible to effectively provide priority support to all items identified as critical.

It is important to make the right resources available from the beginning. In some cases, innovative resource-sharing or approval-routing processes can help to facilitate effective program implementation with limited resources.

2 DEFINITIONS OF KEY TERMS AND ACRONYMS

2.1 Definition of a Critical Spare

As noted in Section 1, the term "critical spare" can mean different things to different people. For example, if you ask a maintenance person what a critical spare is, he or she may suggest it is a part required for a particular maintenance activity, regardless of whether the equipment being maintained has been categorized as critical equipment. If you ask a member of the supply chain, he or she may suggest it is a part with a long lead time or an obsolete part needed for an upcoming outage. Similarly, if you ask an outage manager, he or she may suggest it is an item being furnished for a maintenance activity that is in a critical path. Or finally, if you ask a warehouse supervisor, he or she may suggest that it is a part required for maintenance that is stocked in the warehouse.

In a sense, all of these individuals may be correct, because for each of them the term "critical" is defined and viewed from their particular role within the site's organizational structure. For the purposes of this report, however, criticality of a spare item is based on the function of that item within the critical equipment/system in which it is installed. In that sense, the spare item could be either a replacement part, a whole component, or a consumable that is necessary to support the operation and maintenance of critical equipment.

Members of the ERWG have suggested the following generic definition for a critical spare:

> A critical spare can be defined as a component or part needed to return critical components to service following normal and reasonably anticipated wear and tear, including credible failures that would not normally be predicted via monitoring and trending programs with sufficient advance warning to allow for procurement activities and reasonable lead times for the needed replacement items.

This definition is consistent with the definition published in EPRI 1011861, which defines a critical spare as follows:

> A critical item (component or part) that the licensee has opted to have readily available

Users of this report should recognize that the definition may need to be adjusted to fit individual programs, but the definition used in this report is based on the ERWG definition and is consistent with the definitions presented in previously mentioned EPRI reports.

2.2 Definitions of Key Terms in This Report

This section presents some of the key terminology and acronyms used in the industry when discussing equipment and parts categorization, and materials management.

Contingency part: A part that is not needed to complete the defined scope of work, but may be needed if the defined work scope increases or changes. (EPRI report 1013472 [5]).

Critical component: A component that has been evaluated and subsequently categorized as critical through the implementation of INPO AP-913 (EPRI report 1011861 [1]).

Critical item: A critical component or critical part (EPRI report 1011861 [1]).

Critical part: A part meeting the following criteria (EPRI report 1011861 [1]):

- It is associated with critical equipment.
- Its failure could alter the host (critical) equipment performance and adversely impact plant operations.

Critical Spare: Components or parts needed to return critical components to service following normal and reasonably anticipated wear and tear, including credible failures that would not normally be predicted through monitoring and trending programs, with sufficient advance warning to allow for procurement activities and reasonable lead times for the needed replacement items (ERWG).

Critical spare: A critical item (component or part) that the licensee has opted to have readily available (EPRI report 1011861 [1]).

Obsolescence: The condition of being out of date due to development of better or more economical products, methods, processes, machinery or facilities resulting in a loss of value or competitive advantage. Items may be available in the market but are no longer needed in a specific application. The condition of no longer being available in the market due to lack of manufacturer support. Items are needed in a specific application but are no longer available or supported by the original manufacturer and are difficult to otherwise procure and qualify. (Refer to EPRI report 1016692.)

Obsolete equipment: Items in plant service that are no longer manufactured or supported by the original manufacturer or are otherwise difficult to procure and qualify (See *Nuclear Utility Obsolescence Group (NUOG) Obsolescence Program Guideline, NX-1037, Revision 1,* INPO, in Sect. 8.4).[2]

Required part: A part that almost certainly will be needed to complete the defined scope of work. (EPRI report 1013472 [5]).

[2] Access to INPO reports and materials is restricted to organizations authorized by INPO. The information is confidential and for the sole use of the authorized organization.

2.3 Acronyms

BID background information document

BOM bill of materials

CENG Constellation Energy Nuclear Group

CMMS computerized maintenance management system

CR condition report

EPRI Electric Power Research Institute

ER equipment reliability

ERWG Equipment Reliability Working Group

ID identification

INPO Institute of Nuclear Power Operations

KPI key performance indicator

NC nuclear criticality

NMAC Nuclear Maintenance Applications Center

NSR nonnuclear-safety-related

PC production criticality

PM preventive maintenance

PMB preventive maintenance basis

PSE Plant Support Engineering

QA quality assurance

SKU stock-keeping unit

TAG technical advisory group

VCS V.C. Summer Nuclear Station

3
GENERIC CRITICAL SPARES PROCESS

The purpose of this section is to provide a synopsis of the basic elements involved in a program that proactively addresses critical spares issues.

3.1 Critical Spares Process

Figure 3-1 is a first-level, three-step process map that shows the basic input, process activity, and output associated with a proactive critical spares management program.

Figure 3-1
First-level critical spares program process map

3.2 Overview of a Basic Critical Spares Process

As depicted in Figure 3-2, the process for addressing the spares necessary to support critical equipment involves several key activities. Critical equipment must be identified and then logically grouped to facilitate evaluation and analysis. The anticipated preventive and corrective maintenance tasks associated with each category of equipment are captured, as well as the types and quantities of spare component, part, and consumable items required to support the critical equipment. Subsequently, the infrastructure required to establish and support the proposed spares in plant information systems is established. After final approval is obtained for the new inventory plan for supporting each equipment group, the critical spares are procured, received, and made available to support work on critical equipment.

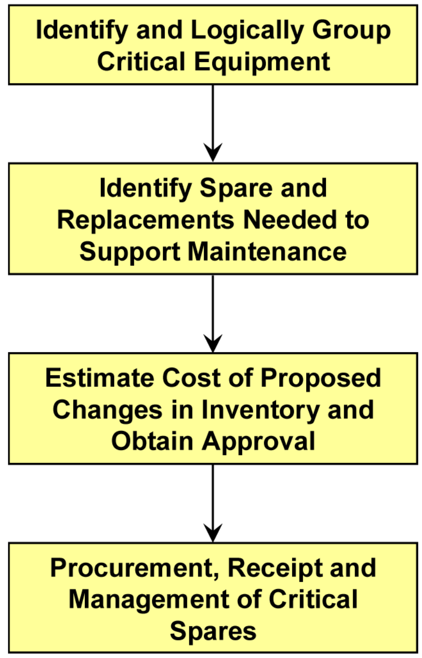


Figure 3-2
Key activities in a basic critical spares process

Figures 3-3 through 3-6 present a basic second-level process map. This map enhances the simplified process by providing another level of detail that may be used when implementing a proactive critical spares program. The first-level diagram depicts what needs to be done, while the second-level diagram provides a basic overview of how a critical spares program might be implemented. The key to the information contained in the process elements is provided in Figure 3-7.

Each of the major elements involved in establishing and implementing a critical spares program is depicted in the second-level process map (see Figures 3-3 through 3-6). The process map is high level and relates typical process steps included in existing plant processes with associated critical spares program activities or elements.

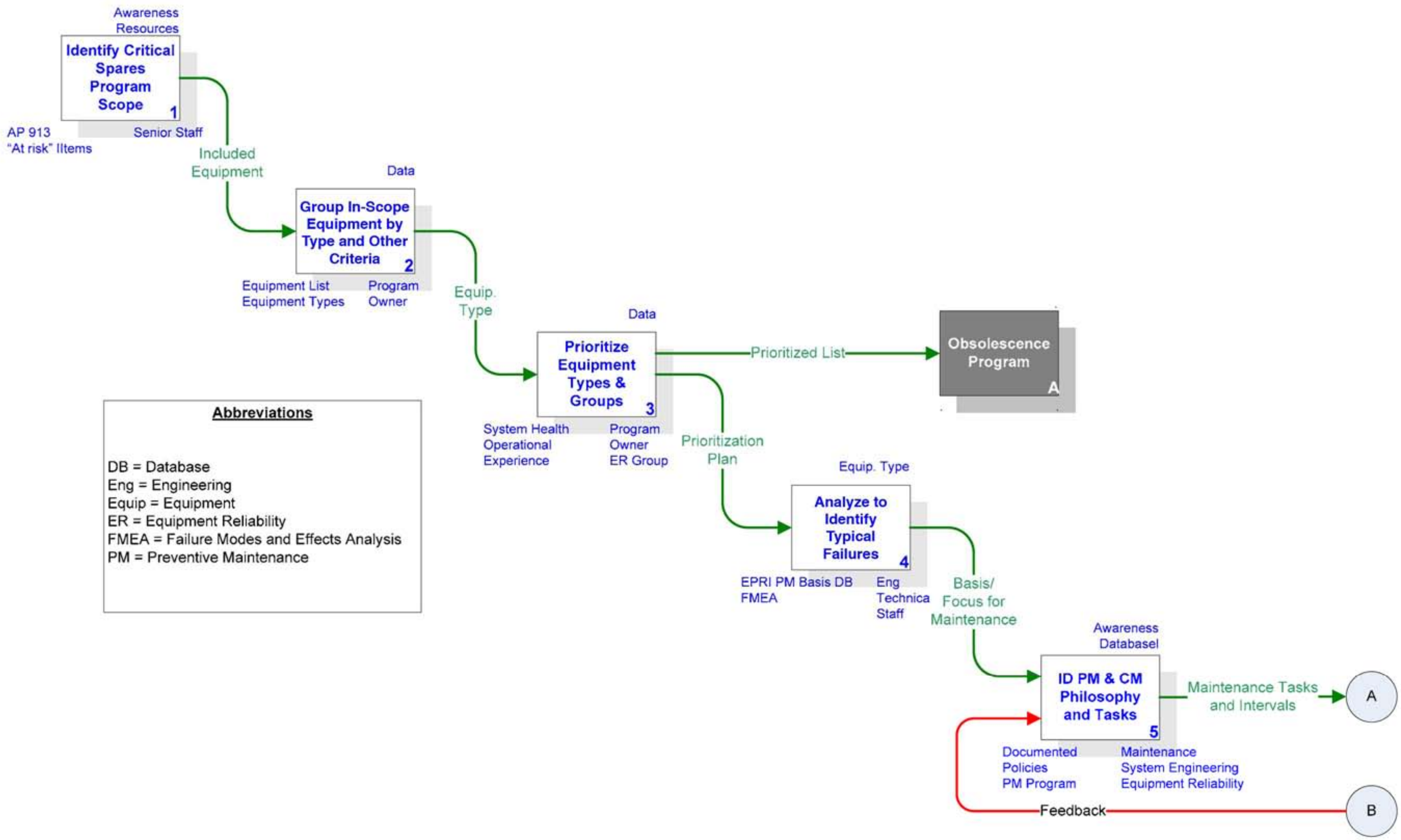


Figure 3-3
Second-level critical spares program implementation process map, 1 of 4

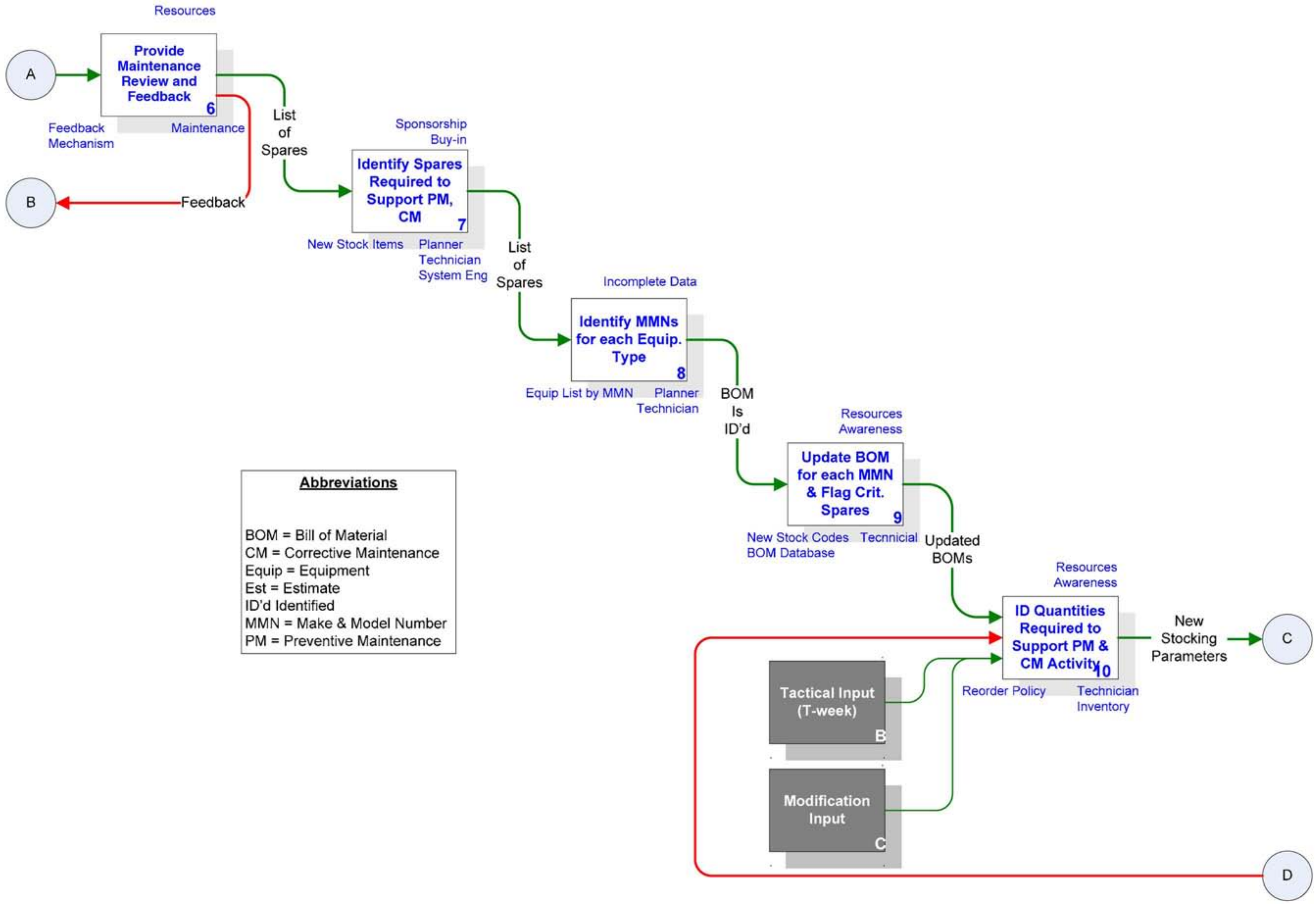


Figure 3-4
Second-level critical spares program implementation process map, 2 of 4

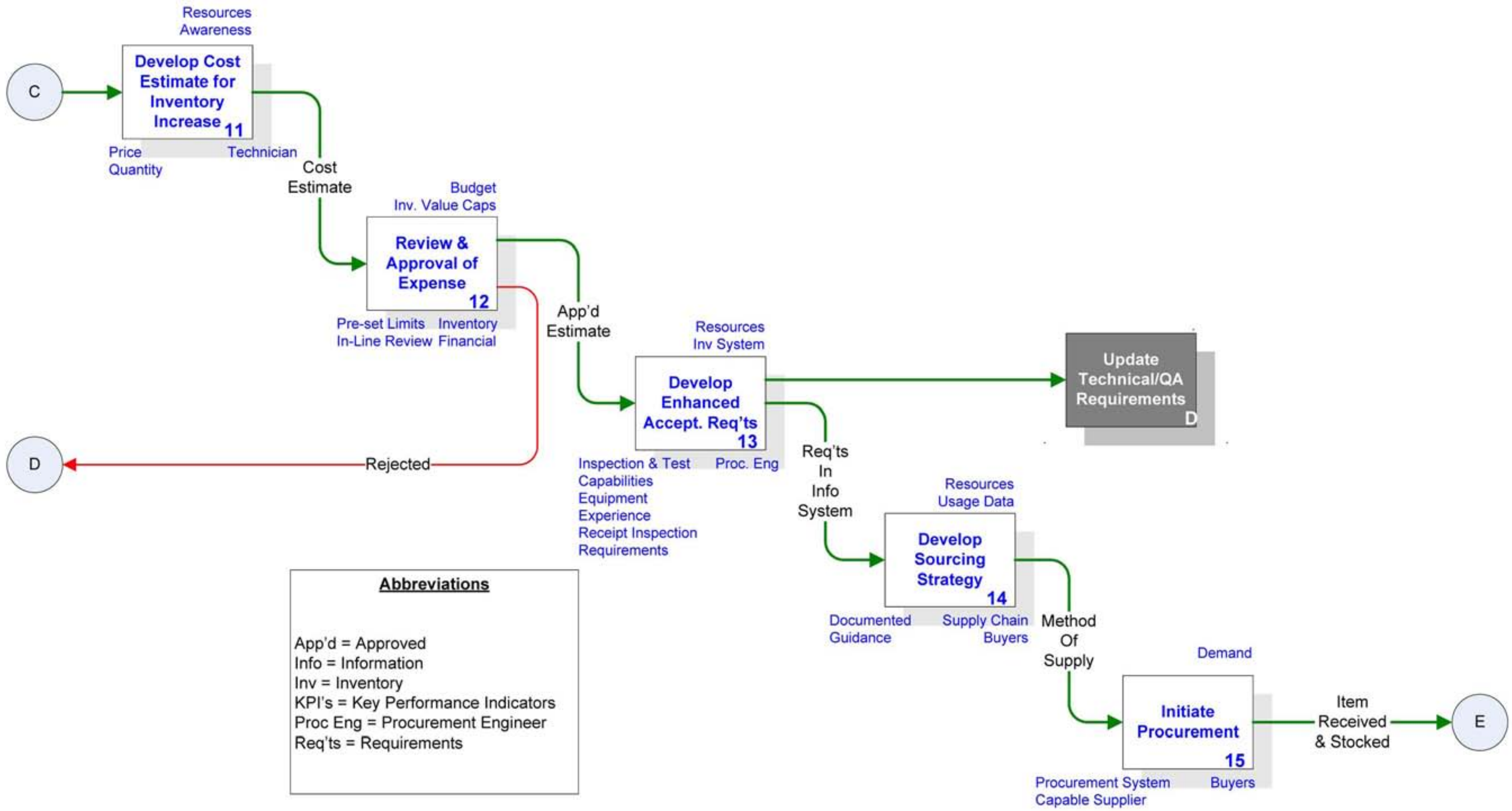


Figure 3-5
Second-level critical spares program implementation process map, 3 of 4

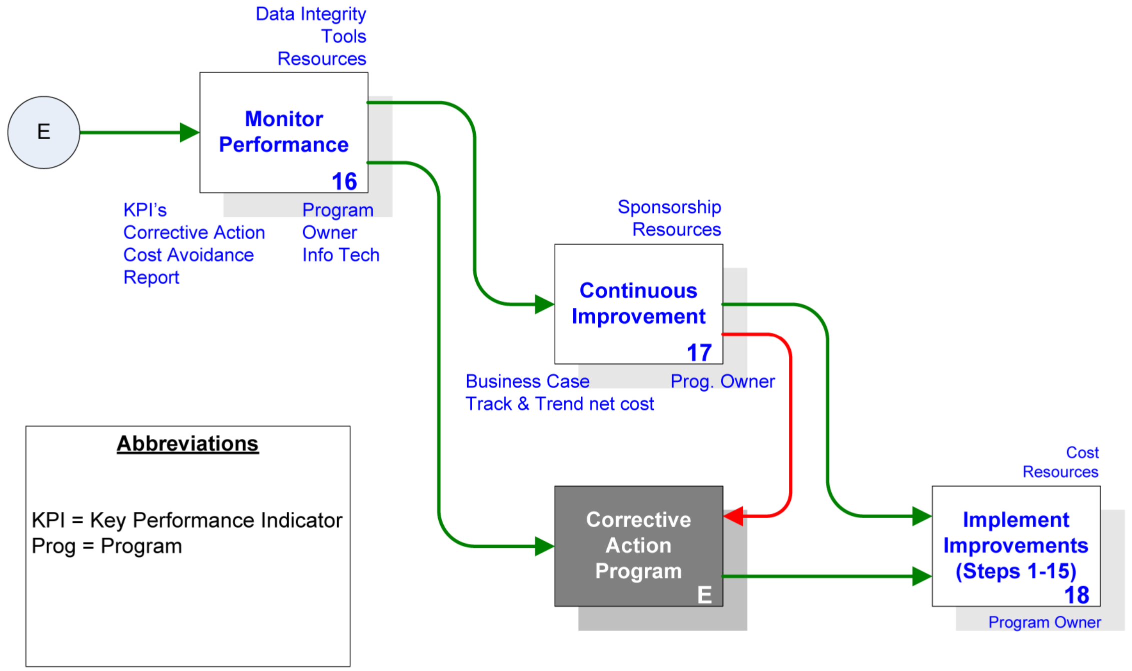


Figure 3-6
Second-level critical spares program implementation process map, 4 of 4

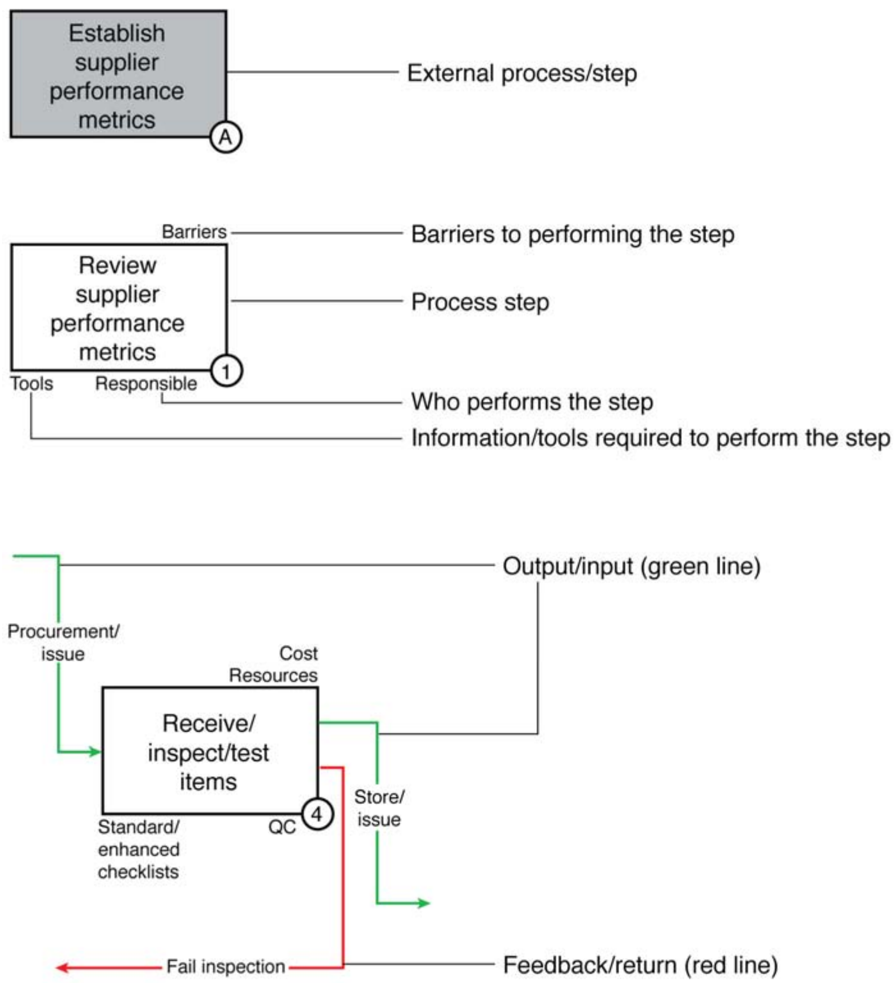
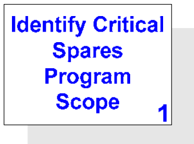


Figure 3-7
Process map key

3.2.1 Identify Critical Spares Program Scope



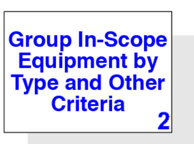
The first step in the generic critical spares program process is to establish the scope of the program. The scope typically includes spare and replacement items required to support maintenance of equipment designated as "critical components" in accordance with *Equipment Reliability Process Description, INPO AP-913* [3].[3]

In addition, the scope is sometime extended when the critical spares process is integrated with other related processes, such as including items that are subject to enhanced receipt inspection or are difficult to repair or obtain due to obsolescence.

Identification of program scope is typically the responsibility of senior management from the organizations that will be responsible for and impacted by identification of critical spares.

Barriers to the successful identification of program scope can include lack of enthusiastic executive support and commitment, lack of integrated critical spare policies and procedures, unavailability of resources, and unclear understanding of the risks and benefits.

3.2.2 Group In-Scope Equipment by Type and Other Criteria



Once the program scope is established, an opportunity exists to sort equipment included in the scope into logical categories or groups. Items in scope can be grouped in different ways such as the following:

- Equipment type (globe valve, gate valve, breaker, pipe support, battery charger, and so forth)
- Discipline (mechanical, electrical, civil, and instrumentation and control)
- Manufacturer (original equipment manufacturer or vendor)
- Functional equipment group
- PM component template group

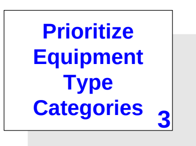
[3] Access to INPO reports and materials is restricted to organizations authorized by INPO. The information is confidential and for the sole use of the authorized organization.

Grouping the in-scope equipment into logical categories can reduce the load on technical resources, yield efficiencies, and prevent duplication of effort in performing subsequent steps. For example, if 40 globe valves are included in the program scope, a knowledgeable and experienced engineering or maintenance resource may be able to develop a “generic” list of parts (by part name) that are critical for globe valves. This list can be provided to a less expensive technician, who can then can use the critical parts identified for a globe valve to identify the corresponding stock codes/catalog IDs that are critical for each of the 40 unique globe valves.

The critical spare in-scope grouping responsibilities should be defined in station program/process procedures. Typically, assistance is needed from subject matter experts from supply chain, engineering, work management, and maintenance organizations to provide input about suppliers, manufacturers, functional equipment groups, and so forth.

Barriers to grouping equipment may include the absence of manufacturer information, equipment type codes, or other data in plant information systems.

3.2.3 Prioritize Equipment Type Categories



Once the groupings are established, they can be prioritized so that the groups that include equipment and spares that will provide the highest value are evaluated first.

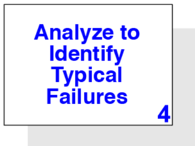
Prioritization can be based on categories that will address the largest quantity of equipment (or tag numbers) in the plant. Prioritization can also be based upon other factors such as system health (work on components that are most likely to need maintenance soon), or available inventory (work on components for which little or no inventory is currently in stock), and high-consequence failures as defined in Table A of the ERWG guidance report, *Industry Equipment Reliability Index Estimator.*

Prioritization should be defined in station program/process procedures. Typically, this is done with assistance from engineering to provide system health data, operation experience information, and the quantity of equipment IDs that can be addressed by evaluating each group.

Barriers to prioritization include difficulty in obtaining data and correlating data such as system health to the equipment IDs included in each grouping.

Prioritization information can be provided to the proactive obsolescence management organization. This information can assist the program in identifying the spare and replacement items for which a replacement solution is necessary and can be used as input to prioritize obsolescence issues.

3.2.4 Analyze to Identify Typical Failures

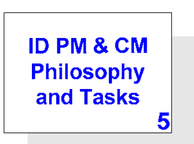


Analysis is performed to identify typical failure modes and mechanisms that apply to the equipment type(s) in the group. Data included in existing maintenance program analysis, the EPRI PM Basis Database, INPO[4] Equipment Performance and Information Exchange System failure database, and procurement engineering failure modes and effects analysis can facilitate completion of failure analysis. Understanding how the equipment fails is useful in identifying the level (component or part) and types of items that should be maintained as spares. Parts that are subject to fatigue or loss of properties should be identified, as well as other failures captured in operational experience, work order history, and other sources. The product of this analysis is an evaluation that provides a basis for determining how the equipment can be maintained in a way that prevents failure from occurring.

Failure analysis is typically the responsibility of technical engineering staff experienced in failure analysis or with deep expertise in the type of equipment being analyzed. Failure analysis and maintenance tasks may already exist for some plant equipment but may not exist for all plant equipment in the scope of the critical spares program. Existing data should be used to the fullest extent possible.

Barriers to analysis may include the absence of previous failure information or analysis for the equipment type(s) included in the grouping.

3.2.5 Identify Preventive and Corrective Maintenance Philosophy and Tasks



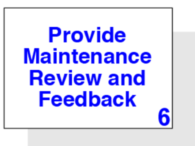
Once failure modes and mechanisms are identified for a piece of equipment, a maintenance philosophy along with maintenance tasks designed to prevent failure can be postulated. This step involves development of appropriate maintenance tasks, task intervals, and maintenance philosophy. The maintenance philosophy can address issues such as the level of assembly replaced (entire component versus parts) and determining if the equipment should be repaired in the field, replaced in the field and repaired in a internal or external shop and returned to inventory, or replaced in the field (and the previously installed item discarded).

[4] Access to INPO reports and materials is restricted to organizations authorized by INPO. The information is confidential and for the sole use of the authorized organization.

Technical individuals experienced in maintaining or operating the equipment type are best suited to determine maintenance philosophy. Failure analysis and maintenance tasks may already exist for some plant equipment, but they may not exist for all plant equipment in the scope of the critical spares program. In addition, tools such as the EPRI PM Basis Database may contain information useful in developing maintenance tasks.

Enlisting the assistance of staff with the depth of knowledge necessary to establish definitive maintenance practices for specific types of equipment can prove challenging.

3.2.6 Provide Maintenance Review and Feedback

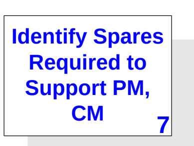


It is not always possible to have experienced maintenance staff develop the initial maintenance philosophy for in-scope equipment that does not already have established maintenance parameters.

As a minimum, the maintenance philosophy (as described in Section 3.2.5) should undergo a formal review by the maintenance organization. Establishing a single point of contact in the maintenance organization that can assign the review to the best qualified individual can facilitate the review and approval process.

The review should ensure that the tasks are practical, correct, and consistent with the plant's approach to maintenance. It is also important to ensure that the intervals are correct, because intervals play a key role in calculating the quantity of critical spares that should be maintained in inventory. Intervals are typically established by the system engineer as part of the PM basis technical evaluation.

3.2.7 Identify Spares Required to Support Preventive and Corrective Maintenance



Once maintenance tasks are established, the spare and replacement parts and items required to complete each task can be determined. Spares in this context include equipment- and component-level items as well as part-level items. Typically, spares include the following:

- Equipment that is replaced instead of repaired
- Wearable parts that are replaced to prior to failure

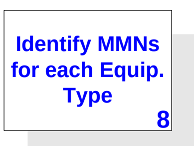
- Consumable items that are replaced each time the equipment is opened (such as seals and certain fasteners)
- Consumable products required for installation (for example, lubricant, room temperature vulcanizing, termination kits, and so forth)
- Special tools or jigs necessary to perform the maintenance tasks

New items or items previously not stocked on-site may be identified when the maintenance tasks and philosophy are reviewed.

Identification of items required to support maintenance task is typically assigned to planners who regularly identify and request material for work orders. Successful completion of this step is dependant upon availability of resources with experience working on or planning maintenance tasks for the equipment.

Additional information for contingency planning can be found in EPRI report 1013472, *Guidelines for Addressing Contingency Spare Parts at Nuclear Power Plants* [5].

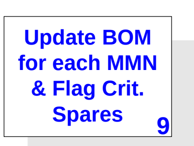
3.2.8 Identify Manufacturer Make and Model Numbers for Each Equipment Type



Once typical maintenance tasks, intervals, and replacement items required for the equipment grouping are identified, it is necessary to identify all of the equipment in the group by plant equipment ID number and obtain manufacturer make and model number information for each equipment ID.

Developing this list of equipment to which the equipment type or group being evaluated applies can be done by personnel such as planners who are familiar with the equipment or technicians who can develop the list using plant information systems, equipment lists, and similar tools.

3.2.9 Update the Bill of Material(s) for Each Make and Model Number and Flag Critical Spares

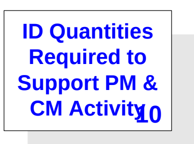


Plant information systems typically associate equipment with the spare and replacement items necessary to maintain them. In essence, this association provides a list of spare components, parts, and consumables used to support maintenance on a given equipment ID. The list includes internal stock codes; manufacturer and vendor part or model numbers; and sometimes classification information such as safety classification, critical classification, and so forth.

In some facilities, a formal BOM exists for all equipment IDs. In other facilities, spare and replacement items may only be linked by work order history that includes requests for the items to perform past work. It is important to identify the items required to support maintenance on critical equipment (critical spares) in the applicable plant information system or document. Any new items will need to be added after stock codes are created. In addition, clear identification of critical spares is necessary to enable plant staff to apply special requirements such as reorder and stocking policies.

BOM maintenance is typically performed by procurement engineers, maintenance staff, or technical material management staff. Once a method of identifying critical spares is determined, plant personnel who are impacted can be trained to recognize how critical spares are identified in bills or material or plant information systems.

3.2.10 Identify Quantities Required to Support Preventive and Corrective Maintenance Activities



After the identity of the critical spares required to support anticipated maintenance activities for critical equipment is identified, the quantity of each critical spare (item) required to support maintenance must be determined so that a warehouse stocking plan can be determined based upon anticipated usage.

Personnel experienced in planning or performing maintenance on the equipment can determine the correct quantity of items required for each preventive and corrective maintenance activity.

As is the case with the steps described in Sections 3.2.5 and 3.2.7, a barrier to determining the quantity of items required for each type of maintenance activity is the availability of resources experienced in maintaining the equipment.

3.2.11 Develop Cost Estimate for Inventory Increase

Develop Cost Estimate for Inventory Increase 11

An estimate of the increase in cost required to support equipment included in the critical spares program can be determined by comparing the expense associated with stocking the critical spares with the cost of stocking the spares previously maintained for the equipment.

In order to determine the estimated increase in cost, stocking parameters must be determined. Stocking parameters usually include minimum quantity in stock (quantity that triggers a reorder), maximum quantity stocked (highest level of inventory desirable), and reorder quantity (quantity of items that should be purchased when inventory falls to the minimum quantity). Ideally, selection of appropriate stocking parameters would ensure that the items required are always available in stock upon demand.

Benchmarking during research for this report did not indicate use of standard algorithms for determining optimal stocking parameters. Rather, experienced inventory personnel determine stocking parameters and update them as necessary. Although mathematical algorithms for determining stocking parameters exist and are embedded in some information systems, they are typically modeled on the manufacturing scenarios and are not always effective in an operations and maintenance environment. Factors that impact operations and maintenance of capital assets, such as obsolescence and unplanned catastrophic failures, are not considered in manufacturing scenarios.

The following factors can be considered when determining stocking parameters:

- Total quantity required to perform planned maintenance in a certain time period (for example, two years).
- Safety stock: the total quantity that should always be on hand to support a worse-case scenario situation.
- Price of the item.
- Total lead-time required to procure the item (internal and external).
- Obsolescence: will the item be available in the future?
- Shelf life.
- Complexity of the item: is the item an engineered spare (special order) or a readily available spare?
- Number of critical and noncritical components containing the stocked item.
- Consequence of component failure, that is, single point vulnerability, short-term limiting condition of operation technical specification, and so forth.

3.2.12 Review and Approve Expenses

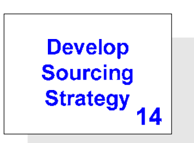
A review process should be established so that the increase in cost to support critical spares for critical equipment is approved. The additional cost can be associated with the program and quantified so that resulting increases in total inventory valuation are anticipated.

3.2.13 Develop Enhanced Acceptance Requirements

Critical spares include safety-related items as well as augmented quality and non-safety-related items. Regardless of functional safety classification, enhanced procurement and acceptance requirements can be developed for critical spares to ensure that they function correctly when installed.

Enhanced procurement and receiving requirements are typically developed by procurement engineering. Some licensees maintain procurement quality improvement programs that include provisions for subjecting critical spares and non-quality-related items that have failed in-service to enhanced procurement and acceptance requirements. Typically, enhanced requirements include accurate item descriptions and receiving inspections that verify certain characteristics or functionality. Additional information on enhance procurement requirements can be found in EPRI report 1016693, *Guidance for Managing the Impact of Procured Item Quality Issues on Generating Asset Economic Performance* [7].

3.2.14 Develop a Sourcing Strategy



As is the case with any stocked item, a sourcing strategy should be developed to find the best means available to keep the item available. Some typical sourcing strategies include the following:

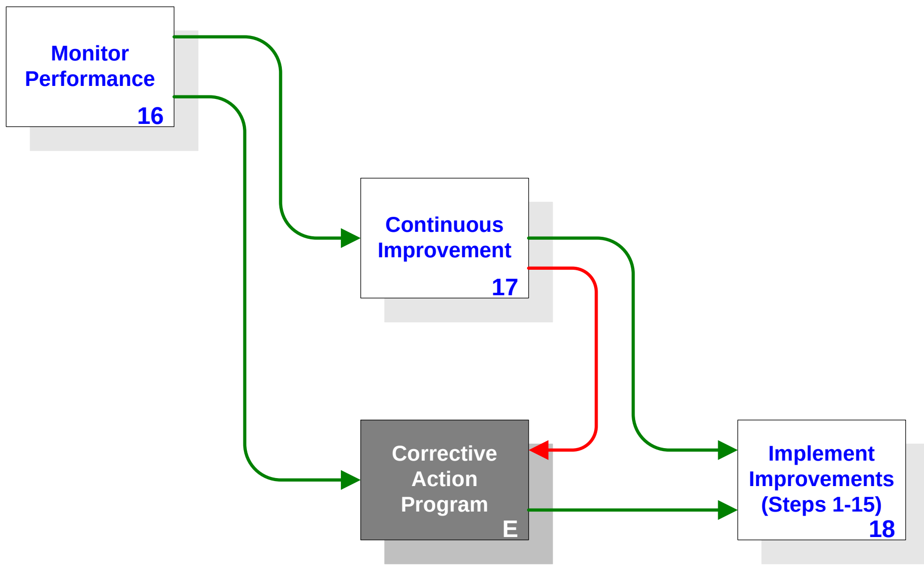
- On-site stocking
- Vendor stocking
- Use of blanket purchase orders

Additional information on sourcing options may be found in EPRI report 109648, *Inventory Optimization in Support of the EPRI Work Control Process Module* [8].

3.2.15 Initiate Procurement

After enhanced procurement requirements and sourcing strategies are determined, procurement of spare and replacement items is initiated: the items are received, subjected to applicable enhanced inspection requirements, and stored. To ensure that critical spares are not inadvertently issued to support work on noncritical equipment, item tags or labels used in the warehouse may be modified to identify the items as critical spares. The maintenance philosophy may specify replacement of individual items versus component replacement. It is important to ensure that procurement requirements and warehouse controls coincide with the maintenance philosophy and application in the field, including considerations such as procurement and control of matched sets of items that must remain together in the assembly, and so forth.

3.2.16 Monitor Performance



As is the case with any program, it is important to monitor the effectiveness of the program and continuously seek to improve program performance and efficiency. In addition to employing existing tools such as the plant corrective action system, monitoring performance of the critical spares program may include development of key performance indicators and collection of data related to the expense and effectiveness of the program.

The critical spares program owner is the main organization that should be responsible for maintaining and monitoring the effectiveness of the program. Station procedures should provide guidance for maintaining and monitoring the effectiveness of the management of critical spares.

4 EXAMPLES OF CRITICAL SPARES PROGRAMS

The purpose of this section is to provide two illustrative examples of how a critical spares program was effectively implemented at a nuclear utility. The first example represents a program developed for a fleet utility, Constellation Energy. The second example represents a program developed for a single-unit utility, SCE&G. These examples are provided for illustrative purposes only, and the user of this report should recognize that other methodologies may be appropriate when developing and implementing a critical spares program at their particular site(s).

4.1 Constellation Energy's Critical Spares Program

The purpose of Constellation Energy's program is to improve inventory availability as well as oversight and control of procurement activities in support of critical components within Constellation Energy Nuclear Group (CENG).

Constellation Energy's critical spares program has two distinct processes. The first is described in their fleet procedure, which is summarized in Section 4.1.1, "Process—Quality." This process is designed to cover day-to-day procurement activities associated with critical components and focuses on quality control and enhanced procurement practices.

The second process is CENG's proactive analysis of components classified as critical, in order to determine the appropriate inventory level of spare parts in support of corrective maintenance. This second process is summarized in Section 4.1.2, "Process—Quantity." This program focuses on both the quantity and quality of spare parts.

4.1.1 Process—Quality

The quality process is intended to address complex items associated with critical components where particular vulnerabilities are known to exist, and a meaningful return on investment is possible when additional (that is, enhanced) procurement measures are applied.

4.1.1.1 Scope of Items

Examples of items subjected to the enhanced procurement determination process may include the following:

- Bistables
- Breakers
- Circuit boards
- Controllers
- Dampers, motor operated
- Emergency diesel generator parts
- Electronic isolators
- Hand switches
- Indicators
- Converters (current to pressure, that is, I/P)
- Motors
- Pneumatic positioners
- Power supplies
- Relays
- Transmitters
- Signal conditioners
- Valves

Simple items such as fasteners, gaskets, and fuses, are typically not evaluated.

4.1.1.2 Criteria Used for Critical Categorization

CENG Procurement Engineering performs a review of all item requests associated with critical components and categorizes as critical any item that is associated with a critical component (as identified in CENG's internal quality review), *and* the item's failure could prevent component from performing its critical function and/or the item is necessary to repair/replace other critical items. If the item is determined to be noncritical by the procurement engineer, no enhanced procurement is required.

4.1.1.3 Factors to Determine the Use of the Enhanced Procurement Process

CENG's Enhanced Procurement Guideline is used to determine if the enhanced procurement process should be used. The following factors are used as a guide to determine whether the enhanced procurement process should be used:

- Review the internal and industry operating experience and failure history of the item.
- Contact the vendor, if known, for awareness of any problems or concerns (for example, 10CFR21 reports).
- Determine if this is an error-likely procurement (for example, rush, one-time order, or new equipment).
- Review existing regulatory procurement requirements (for example, American Society for Mechanical Engineers [ASME], augmented quality, and safety-related)
- Review procurement specification. If one exists, should it be updated? If one does not exist, should there be one?
- Determine if critical characteristics have been identified.
- Consider service life, shelf life, and storage requirements.
- Determine if vendor has known limitation. (Review with Procurement Quality Assurance Unit if necessary.)
- Determine if there are any special processes involved (for example, nondestructive examination and welding).
- Determine if fits, tolerances, clearances, or acceptance criteria are included.
- Determine if there is benefit in maintaining traceability for nonnuclear-safety-related (NSR) items.
- Determine if there are any special PM activities for spares or plant equipment need to be generated or modified.
- Consider reliability testing for items that have not been proven in industrial applications (for example, new design, new product line, or new application for the product).
- Determine if the item was reverse engineered.
- Determine if the item is a one-of-a-kind or original design.
- Determine if the item was procured from other than the original equipment manufacturer.
- Determine if there is existing enhanced procurement history for a similar item.
- Determine if bench testing has been performed before installation.

If the enhanced procurement process is required, the procurement engineer provides a critical spares acceptance plan, which outlines the technical/quality requirements and acceptance criteria, along with receipt inspection requirements. The entire procurement package is then forwarded to the CENG buyer for processing.

4.1.2 Process—Quantity

This quantity process addresses all replacement parts whose failure would prevent the component from performing its critical function and those parts necessary to replace them. It results in a more comprehensive list than the normal list of preventive or normal maintenance wear parts but does not include all parts of the component. However, it does include parts that have quite low failure rates. This process identifies items that have an estimated failure probability of up to once per 10–20 years (basically the remaining life of the plant) or those parts with an estimated probability of failure less than the duration of the PM activities that will replace the part. A database houses research information associated with all of the critical components that have been analyzed.

4.1.2.1 Prioritization of Items

CENG's prioritization scheme uses experience to obtain maximum impact upfront by researching the following:

- Twenty-four months of Constellation operating experience
- Current or future planned maintenance
- Industry operating experience
- Component probabilistic risk assessment

4.1.2.2 Critical Component Spare Part Stock List Process

CENG's critical component spare part stock list process flowchart is shown in Figures 4-1 and 4-2.

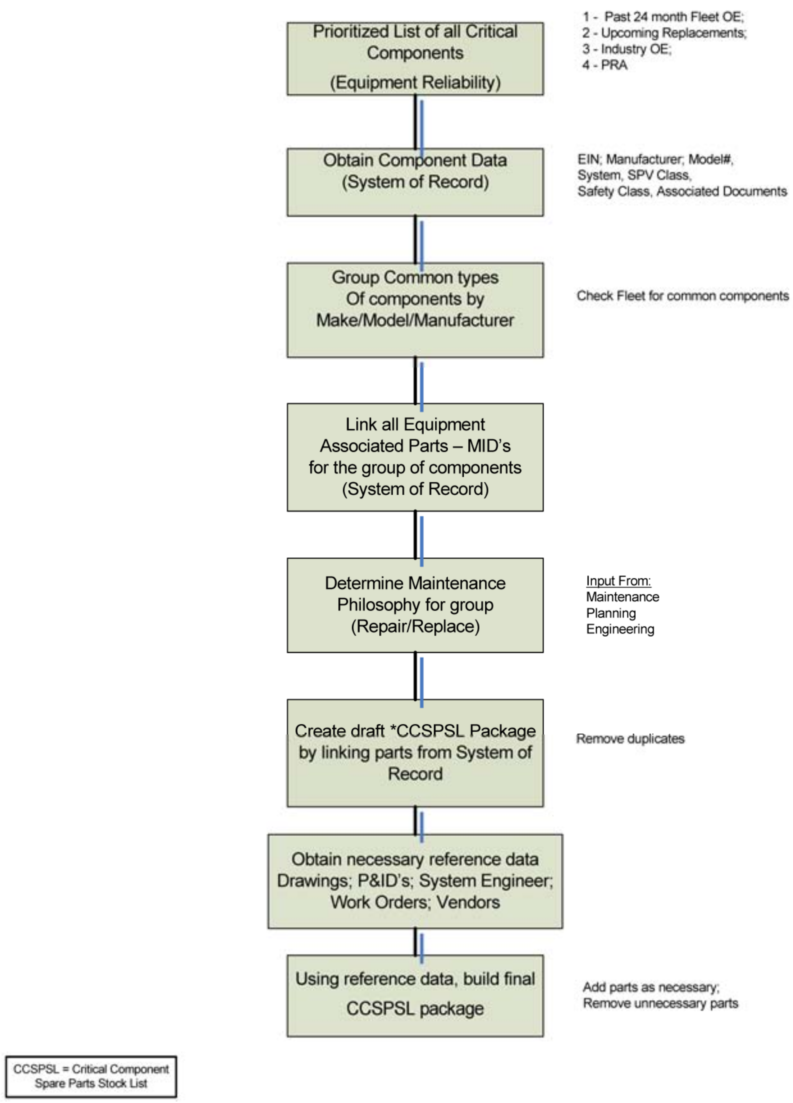


Figure 4-1
Constellation critical component spare parts stock list process, part 1

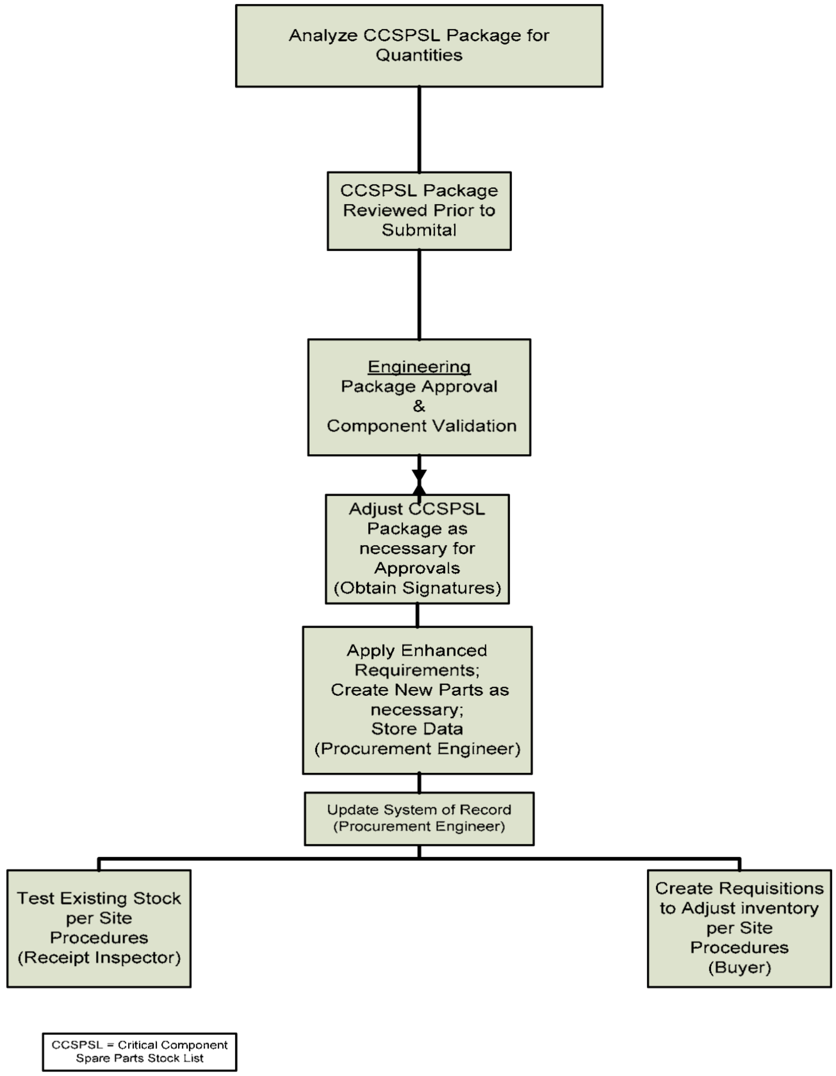


Figure 4-2
Constellation critical component spare parts stock list process, part 2

4.2 VCS Critical Spares Determination Process

The purpose of SCE&G's VCS program is to provide guidance for development of the BOMs and the process of determining critical spares for critical plant components. VCS's critical spares determination procedure outlines the process and is summarized in Section 4.2.1.

4.2.1 Defining Critical Equipment and Spares

VCS defines a critical spare as a part or item that meets the following criteria:

> The item is a replacement for or a part of a Functional Importance Level 1 component needed to support plant operation. This includes Nuclear Criticality Level 1, Production Criticality Level 1 and Other Criticality Level 1 components.

Items that meet these criteria but that site personnel elect for whatever reason not to keep in stock (as indicated by a min/max of 0/0) are not considered to be critical spare parts.

Nuclear Criticality 1 (NC1) is defined as the following:

> Loss of a function of this component will cause the loss of a Maintenance Rule–Risk Significant function.

Production Criticality 1 (PC1) is defined as the following:

> Loss of a function of this component will cause a reactor or turbine trip or a down power >10%. Note: these are Single Point Failure Components.

Other Criticality 1 (OC1) is defined as the following:

> Loss of a function of this component could cause the unplanned release or discharge of radioactive material to the environment. Loss of a function of this component will cause an LCO [limiting condition of operation] of ≤72 hours.

All PC1 components have had their BOMs developed and reviewed for completeness to ensure ER. PC1 components have been determined to be single point vulnerable and whose loss of function will cause a reactor or turbine trip or down-power >10%. All non-PC1 components will have the existing parts cross-referenced in the computerized maintenance management system (CMMS) material database used as the BOM; current min/max levels for non-PC1 components are assumed to be correct and adequate. Determination of which specific items are classified as critical spares for a component is made by the materials management and procurement engineering organizations. Recommendations are then provided to Plant Support Engineering (PSE) and Planning for their review and approval.

4.2.2 BOM Development for PC1 Critical Components

The manufacturer and model number is selected from the PC1 master component list for any component for which a BOM is being built.

The equipment list is printed for the manufacturer and model number of the chosen component. A cursory review of the component equipment criticality classification is performed. If the component classification is deemed to be wrong or in question, additional review is performed and approval by PSE is required to change or declassify the component. A review of the equipment list and BOM is performed; the existing BOM is used if it is available; if so, the BOM table is taken to "draft" status with an explanation given for any action taken in an attached notebook to the BOM table. A condition report (CR) is generated in the corrective action program for the procurement engineer's review and reapproval of the BOM as required; a BOM is developed for each model component, and a stock number is obtained as necessary.

Wherever possible, the BOM is built from vendor information showing the parts breakdown for the applicable component model. Vendor drawings, vendor manuals, design documents, construction BOMs, and so forth, are consulted as available to identify the BOM parts. Component information contained in the CMMS and other documents is verified to match the component manufacturer and model number as found on the component in the plant; discrepancies are resolved in the CMMS as necessary. The BOM table and equipment forms are prepared for each model component. A notation is made on the BOM table form if the component is a manufacturer's recommended spare. From the CMMS material database, VCS stock-keeping units (SKUs) are matched to the manufacturer's part number and recorded on the BOM table form. A review of the parts cross reference for the subject model and/or equipment ID in the CMMS Material Database should be done for completeness and accuracy of the BOM. The component BOM is updated as required and entered into the CMMS material database in "draft" status.

4.2.3 Critical Spare Determination

Each background information document (BID) and preventive maintenance basis (PMB) for PC1 components are reviewed during the critical spare determination. For each functional failure mode, a determination is made as to whether existing PM, inspection, and/or testing programs are adequate to prevent an unplanned failure of the component, that is, a failure that would cause an upset to the plant work management schedule resulting in "emergent" work. In cases where existing programs, PM programs, and so forth, were inadequate to prevent such failures from occurring, a determination would be made about which parts and quantities would be required to prevent such a failure of the component. These parts are identified as recommended spares on the BOM. Similarly, PM strategies for components of all other levels of criticality are reviewed to ensure that they adequately address necessary spare parts coverage by reviewing BIDs and PMB for all new, retired, and revised scope PM programs. A review is also performed of BIDs and PMB by component at all levels of criticality for end-of-life considerations. Verification is performed to ensure that such components are properly identified in the CMMS as having shelf life requirements placed on them. The CMMS is updated as necessary to ensure that proper documentation for justification exists.

For components with existing stock inventory identified as having shelf life that has *not* been previously identified, a CR is generated and action assigned to Receiving Inspection to evaluate currently stocked items against applicable shelf life criteria. VCS stocking levels are checked to make sure they are adequate by comparing current recommended spares that already have a VCS SKU to the manufacturer's recommended stocking levels and adjusting as necessary. A VCS SKU is created for all newly identified recommended stocked spares, and the applicable BOM table in the CMMS material database is updated with the new stocking numbers. For all identified recommended spares, a review is performed of all applications, PM frequencies, parts usage, and so forth, to determine the appropriate min/max stocking levels. The current and newly recommended min/max levels are recorded on the appropriate BOM. The CMMS material database is updated with min/max levels associated with newly created, retired, and revised scope PM programs for non-PC1 components. The BOMs are sent to Plant Support Engineering and Planning for their review and approval.

Any changes made as a result of the review/approval process are entered into the CMMS including adjusted min/max stocking levels An update to the CMMS is made to identify the components with VCS SKUs associated with NC1, PC1 and OC1 components as critical spares. The BOM status is changed to “approved.” Finally, the BOM index for each BID is sent to the responsible plant support engineer for incorporation into the BID.

5
BENCHMARKING APPROACH AND RESULTS

The purpose of this section is to summarize the approach used to benchmark the two utility programs described in Section 4 and to summarize the results obtained through the benchmarking questionnaire.

5.1 Benchmarking Approach

5.1.1 Candidate Plants

Volunteers were initially sought from members of the TAG for benchmarking visits. VCS and Calvert Cliffs responded and agreed to host visits so that firsthand information regarding their respective critical spares program could be obtained.

5.1.2 Benchmarking Questionnaire

TAG members assisted in developing a questionnaire, which comprised 16 questions and was used to gather comparative data from the two benchmarked plants.

5.1.3 Benchmarking Visits

Table 5-1 summarizes the two benchmarking visits conducted in support of this project.

Table 5-1
Summary of benchmarking visits

Plant Name	Date of Benchmarking Visit
V.C. Summer Nuclear Station	4/27/2009
Calvert Cliffs Nuclear Power Plant	5/28/2009

5.1.4 Summary of Benchmarking Questionnaire Responses

Table 5-2 summarizes the responses provided by both Constellation Energy and SCE&G to the critical spares benchmarking questionnaire.

Table 5-2
Summary of benchmarking questionnaire responses

	Question	Responses	
		VCS	**Constellation Energy**
1	What definition of critical spare has been adopted for your plant's use?	A part or item of material which meets the following criteria: 1. The item is a replacement for or a part of a Functional Importance Level 1 component needed to support plant operation. This includes NC1, PC1 and OC1 components. 2. Items that meet the criteria above but that VCS elects for whatever reason not to keep in stock (as indicated by a min/max of 0/0) are not considered critical spare parts.	All replacement parts whose failure would prevent the component from performing its critical functions and those parts necessary to replace them. This is a more comprehensive list than the normal list of preventive or normal maintenance wear parts, but does not include all parts of the component. For instance, even though valve bonnets may be "replaceable," they are not typically stocked as critical spares. However, this list does include parts that have quite low failure rates. The basic approach is to identify items that have an estimated failure probability of up to once per 10–20 years (basically the remaining life of the plant) or those parts that have an estimated probability of failure less than the duration of the PM programs that will replace the part.
2	How are critical spares identified (based on equipment type, tag number, and so forth)?	1. Cat IDs are based on definition of PC1, NC1, and OC1. 2. ER organizations prepared background information in the Integrated Equipment Reliability Improvement Program (i-ERIP). BIDs for various types or logical groupings of equipment (may have been based on PM)—documents including maintenance strategies were done as part of the ERIP (AP-913 project). 3. Prioritization was based on equipment ID, and work was grouped by manufacturer, component type, and so forth 4. Contractors with the right expertise were also brought into group to do the work.	Using experienced procurement engineers with approval of Engineering. Packages are produced containing critical spare parts stocking list and the system of record is updated to reflect the classified spare parts.
3	Which plant organization "owns" the critical spares program?	Supply Chain owns the program, but indirectly, Engineering is the ultimate owner. The department has five Procurement Engineering staff members (three Electrical and two Mechanical).	Supply Chain.

Table 5-2 (continued)
Summary of benchmarking questionnaire responses

	Question	Responses	
		VCS	Constellation Energy
4	Which plant organization(s) participate in the determination of required critical spares (Engineering, Maintenance, and so forth), and what role does each play?	Contractors (hired by Supply Chain) with the right expertise develop the strategies that are ultimately approved by Engineering.	Supply Chain recommends based on discussions with Planning, and Maintenance and Engineering approves.
5	How is the critical spares project funded or staffed (project, base level of effort and so forth)?	Corporate funding is available as apart of i-ERIP program; 10 staff members are engaged in the process. The employees are motivated by an annual bonus, which helps to maintain high productivity. No taxes are paid on the inventory in South Carolina. No specific budget is set for critical spares. Hardware purchases are given priority.	Mission Critical Initiative/Project is funded by Corporate.
6	How and where do the critical spares decisions get documented?	1. BOM is used as a basis for structuring critical spares, which has min/max values. 2. The major decisions are based on engineering experience using plant process guidelines as tools; use of max-min criteria and so forth	Both in the system of record and in packages.
7	What information is provided to your supply chain to determine stocking strategy?	Minimum stocking level is determined by corrective maintenance process. Decision is based on experience, ROP (reorder point), and so forth. This process is somewhat subjective.	ROP/ROQ (reorder quantity) should be adjusted to maintain adequate emergency stock to support corrective maintenance on the critical component. This depends on lead times, number of components supported, and usage rates, as well as other variables on a case-by-case basis.
8	How are stocked items identified in your system (safety, emergency, and so forth)?	BOMs, ROP, and prioritization are flagged.	Maximum information includes a “critical” field with options of critical/not critical/unknown.
9	What approvals are required for the removal of critical spares from stock?	Manager’s approval is needed for removal of critical spares from stock; has to run through Procurement Engineering to avoid “accidental” changes or disposal. The removal of critical spares from the list is also checked against obsolescence; the parts are verified with maintenance, with approval from Procurement Engineering for max/min criteria and due to surplus of old equipment.	Normal approval process, stocking levels for maintaining an emergency inventory are built into the ROP/ROQ.

Table 5-2 (continued)
Summary of benchmarking questionnaire responses

	Question	Responses	
		VCS	Constellation Energy
10	What are your critical spares program strengths and weaknesses?	Strengths: management support, maintenance support, planning, and scheduling runs the process; PSE provides the documentation, focuses on timing, good feedback process, successful T minus 4 to 6 weeks; and PSE is motivated to buy-in and fully supports the process, and their success are tied to bonuses. Weaknesses: lack of good equipment information; the plant was built in the early 1970s; construction was completed in 1978 but went commercial in 1984. The equipment database lacked good information for some, which needed walkdowns for verification. The program ended when funding disappeared. Many BOMs had to be built from scratch.	Strengths: Program includes Enhanced Procurement for all parts procured associated with Critical components; Detailed analysis of individual Critical Components by qualified personnel; Fleet wide process; FTE effort with contractor support; Several items have failed new receipt inspection requirements preventing installation and failure during operation; Greater than $1M worth of spare parts have been added to stock in support of critical components; NSR Critical parts require Enhanced Procurement; Program has been a success, with initial program scope already being exceeded, and an additional 20,000 components yet to be analyzed; program is in year two of a six year process. Weaknesses: Lack of availability of required information for NSR items; Engineering is on LOE only; Scoping of the project should include the amount and quality of information available in support of critical components; Project should be staffed with the most experienced personnel available, consider back filling their day to day roles with contract support; Incorporate more resources to build parts lists in the business case based on the information we now have.
11	11. What are your program successes?	Effective prioritization. 2. Good shape on Barton transmitters, power supplies when they became unavailable.	Several items have failed new receipt inspection requirements preventing installation and failure during operation. Greater than $1 million worth of spare parts have been added to stock in support of critical components. NSR critical parts require enhanced procurement.
12	What lessons have been learned (what could have been done better) from your critical spares program development and implementation?	Learned a lot from First Energy (Dan Philipps) and Progress Energy. Communications among the industry peers are very important, so that implemented processes are based on successful industry experience.	Scoping of the project should include the amount and quality of information available in support of critical components. Project should be staffed with the most experienced personnel available, consider back-filling their day-to-day roles with contract support. Get stakeholder buy in prior to execution (we did this, and it proved to be a very useful tool).
13	Has the program completely accomplished your original goals, or is there still work remaining to be done?	1. Met original annual goals. 2. Could complete all equipment as incremental work over the life of the plant. 3. The project has set a goal to roll in six years; work is in progress, and it is in its second year.	We are satisfied with our process and procedures; we have exceeded our initial intent of the program, but there are still more than 20,000 components to analyze. We are starting the second year of a six-year process.
14.	If you could start all over, or make any desirable changes, what would be different?	1. Motor control centers were evaluated individually; should have been reviewed generically. 2. PM programs should have been evaluated for critical components in the system.	Incorporate more resources to build parts lists in the business case based on the information we now have.

Table 5-2 (continued)
Summary of benchmarking questionnaire responses

	Question	Responses	
		VCS	Constellation Energy
15.	What measures have you had to take to address the SOX?		No additional measures have been implemented due to critical spares project; there are standard procedures in place that cover SOX concerns.
16.	What key performance indicators (KPIs) are you currently maintaining?		Fleet KPI: Failure of critical components due to parts failures based on vendor and/or supply chain issues. Site KPIs: Critical components complete Critical parts availability Critical part failures prior to issue Critical part failures after issue but prior to operations

6
INVENTORY PLANNING CONSIDERATIONS

The purpose of this section is to provide a number of considerations when determining the need to place a critical spare in inventory and when considering the many dynamics from both supply and demand perspectives.

6.1 Availability of Critical Spares

One major area of treatment that can be affected by the criticality determination is the availability of critical spares. Because the item has been determined to be critical, the licensee should treat it more conservatively when determining the most appropriate level of availability. In fact, it may be prudent in some cases to ensure that some critical items (replacement parts or whole components) are immediately available if and when they are needed by placing them in inventory.

> **As noted previously in this report, just because there is a potential need for the critical item does not mean that the licensee needs to stock it in inventory.**

Instead, the licensee should use a least-cost method for meeting the material availability requirements that have been defined.

6.1.1 ER Impacts

Each site's ER program actions impact material demands to some extent. Preventive maintenance and planned replacements drive a cyclic and predictable demand for items that can be anticipated, planned, and scheduled. Condition monitoring and predictive maintenance can provide projections of future material requirements at various levels of confidence and with varying lead times.

As reliability increases as a result of ER program efforts, the demand frequency due to random in-service failures should decrease. But as noted in the preceding paragraph, the overall goal is to minimize the risk of an unplanned equipment failure for which there are no parts available to restore it to service in the time required.

6.1.2 Least-Cost Method for Meeting Defined Material Availability Requirements

Section 4 of EPRI report TR-109648 provides detailed guidance for performing a material sourcing evaluation, which remains relevant in the context of implementing a critical spares program. Report TR-109648 states in part:

> The specific engineered spare parts, normal operational materials, and construction support materials needed to support plant operation, maintenance, and modification and their demand characteristics are identified. Historically, the assumption at this point was that all required materials would then be placed in inventory at the plant site to ensure their availability when needed.
>
> The key recommendation at this point for optimizing on site inventory is to perform an evaluation to determine the optimum method of satisfying the identified material availability requirements. On-site inventory is only one potential method of making the material available, and may not be the overall least cost method for many parts and materials. The evaluation should identify a planned method of supply for each material, which satisfies the availability need at the lowest total cost. [8]

Figure 6-1 illustrates how the risk increases when various options are considered for meeting material availability requirements.

The licensee should evaluate options for meeting anticipated material demand and consider the risk associated with each option. Figure 6-1 illustrates that risks associated with equipment unavailability will increase as other options are considered. Similarly, the confidence in being able to have the necessary replacement items when needed will decrease. The figure also illustrates that having the items on-site and in stock minimizes the risk to the lowest possible degree. Contributors to the risk factor are the following issues:

- Lead time needed to procure and deliver the replacement item
- Obsolescence of the replacement item (worsened if the licensee is unaware prior to procuring the item)
- Physical changes to the item about which the licensee is unaware
- Changes in manufacturer or manufacturing location

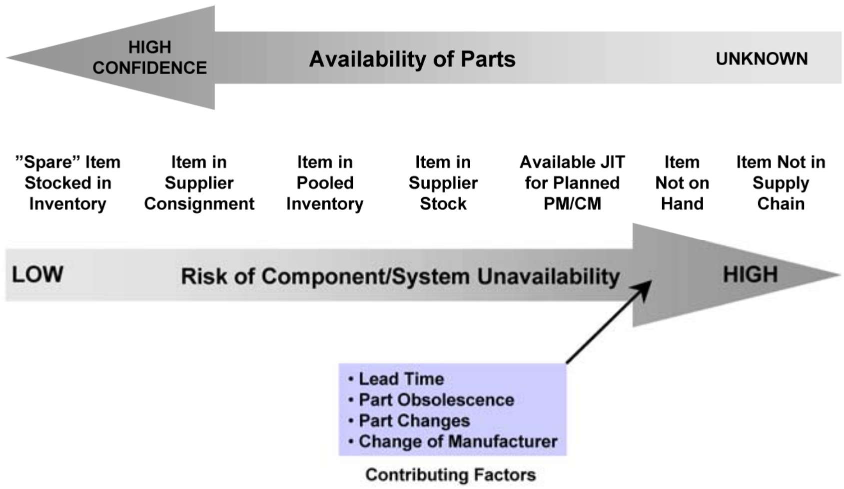


Figure 6-1
Risk of component unavailability versus availability of critical spares

6.2 Inventory Stocking Practices

Practices used to establish inventory stocking parameters such as minimal allowable quantity on hand, safety stock, reorder quantity, and maximum desired inventory on hand should be well understood with a clearly defined strategy that is consistently applied.

6.2.1 Size and Composition of Inventory

The size, scope, cost, and management of inventories at nuclear power plants has been a subject of debate since the fleet of U.S. nuclear power plants became operational. For the purposes of this report, the licensee should consider inventory as analogous to an insurance policy. The items in stock provide the licensee with immediate parts availability if and when they are needed. This immediate availability eliminates the risk associated with not having the replacement item when it is needed, but like an insurance policy premium, immediate availability (that is, stocking in inventory) also comes with a cost. If the stocked item is never needed, the cost of keeping the item in stock is like the premium paid against an insurance policy that is never executed.

Therefore, the cost of maintaining an item in inventory should be weighed against the cost of not having it when it may be needed and the subsequent cost of plant equipment being unavailable. This is illustrated in Figure 6-2.

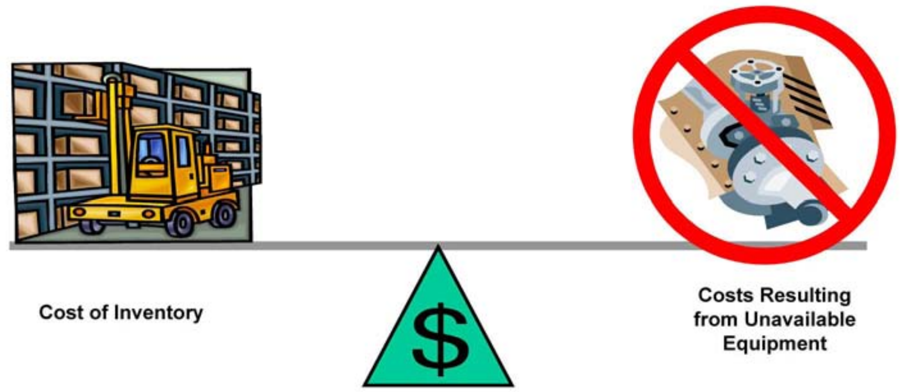


Figure 6-2
Cost of inventory versus cost of equipment unavailability

6.3 Inventory Management and Optimization

6.3.1 General Guidance

Although critical items are typically not handled any differently once they are placed in stock, the fact that they are identified as being critical in the inventory management information system and sometimes physically tagged as critical items ensures that licensee staff consider item criticality so they may better manage and justify their inventory. For example, identifying parts as critical and noncritical provides the licensee with the ability to determine the percentage of inventory that is composed of critical items (spares). Normal inventory reports can be modified to include a delineation of critical versus noncritical items, which can then be used to prioritize usage and budgeting for additional spare part procurements.

7 ENHANCED PROCUREMENT FOR CRITICAL SPARES

The purpose of this section is to expound on the concept of enhanced procurement practices for critical spares introduced in Sections 3.2.13 and 4. In some cases, the licensee may opt to enhance the specification, procurement, and acceptance of an item designated as critical, so as to gain some additional assurance that it will perform its critical functions. The amount of enhancement and rigor will vary from item to item and among licensees.

7.1 Determining the Critical Attributes of Critical Spares

Enhanced procurement and acceptance requirements for critical spares should be based on important characteristics of the critical items. For the purposes of this report, a critical attribute is defined as follows:

> Those important design, material, and performance attributes/features of a critical item that if deemed necessary to verify, will provide additional confidence that the item will perform its intended critical function

Critical attributes of the part may be determined to assist procurement engineering with the development of the technical procurement requirements and the acceptance plan.

7.2 Developing the Procurement Requisition and Specification

The licensee’s existing process for developing a procurement requisition and specification (technical, quality and documentation requirements, if applicable) should be used for procuring critical spares. The critical spare’s technical procurement requirements should be a translation of the part’s critical attributes into procurement requirements. The quality requirements specified should reflect the supplier’s capabilities through their own quality assurance (QA) program/practices to ensure that technical requirements are imparted to the critical part. Documentation requirements should be specified accordingly to ensure that specified quality requirements, if any, have been implemented.

7.3 Acceptance Planning for Critical Parts

In some cases, the licensee may opt to implement certain acceptance activities to ensure that the critical part was manufactured in accordance with its design and achieve reasonable confidence that it will perform its critical functions. Acceptance activities that may be selected by the licensee can include any of the following:

- Supplier/manufacturing oversight
  - Performance-based evaluation of QA programs and quality controls
  - Manufacturing surveillance
  - Source inspections
- Inspection of critical parts upon delivery
  - Receipt Inspection inspects items identified as critical in accordance with the acceptance criteria developed by Procurement Engineering. Any discrepancies found during their inspection may be documented in accordance with existing site procedures (corrective action program/receipt hold order, and so forth). Upon completion of the inspection activity, the normal site procedures and process should be followed for item movement and the associated procurement package.
- Inspection and testing of critical parts after they have been installed

In some cases, it may be necessary for the licensee to designate the procurement category as "augmented quality" to ensure that these acceptance activities occur.

For critical parts installed in non-safety-related critical equipment, the licensee is afforded wide latitude in determining the most appropriate means to implement the acceptance activities. For instance, the licensee is not required to impose the same rigor and processes to accept a critical part installed in a non-safety-related critical component as is required during a commercial grade dedication or the procurement of a basic component from an approved nuclear supplier. This is because the non-safety-related critical host component is controlled outside of the licensee's 10CFR50 Appendix B QA program, and as such, the licensee can decide which elements of its QA program, if any, should be applied to the procurement and acceptance of the non-safety-related, critical part.

Examples of how the acceptance of a critical part installed in a non-safety-related component may vary include the following:

- Using procurement engineers, technicians, others to conduct/participate in the acceptance process in lieu of certified auditors or inspectors
- Documentation and/or certification provided by the supplier may be optional and may not need to be validated with a performance-based vendor evaluation
- Placing more reliance on postinstallation testing or postmaintenance testing

7.4 Purchasing Activities

For the purchase of critical parts installed in non-safety-related critical equipment, the licensee may opt to limit or restrict the use of credit cards, if tighter controls than for other non-safety-related purchases are deemed appropriate. Existing purchasing processes should be applied for purchases of critical parts installed in safety-related equipment.

8 REFERENCES

8.1 In-Text References

1. *Considerations for Developing a Critical Parts Program at a Nuclear Power Plant*. EPRI, Palo Alto, CA: 2007. 1011861.

2. 10CFR50.65, Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, Nuclear Regulatory Commission, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, D.C., 1997.

3. *Equipment Reliability Process Description, INPO AP-913, Revision 1*. INPO, Atlanta, GA, 2001. (Available only to INPO members.)

4. *Critical Component Identification Process—Licensee Examples: Scoping and Identification of Critical Components in Support of INPO AP-913*. EPRI, Palo Alto, CA: 2003. 1007935. (Available only to INPO members.)

5. *Guidelines for Addressing Contingency Spare Parts at Nuclear Power Plants*. EPRI, Palo Alto, CA: 2006. 1013472.

6. Sarbanes-Oxley Act of 2002 (Public Law 107-204, 116 Stat. 745).

7. *Guidance for Managing the Impact of Procured Item Quality Issues on Generating Asset Economic Performance*. EPRI, Palo Alto, CA: July 2008. 1016693.

8. *Inventory Optimization in Support of the EPRI Work Control Process Module*, EPRI, Palo Alto, CA: 1998. TR-109648.

8.2 Regulations and Regulatory Guidance

10CFR50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Facilities, Nuclear Regulatory Commission, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, D.C.

10CFR50.2, Definitions, Nuclear Regulatory Commission, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, D.C.

10CFR21, Reporting of Defects and Noncompliance, Nuclear Regulatory Commission, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, D.C.

8.3 Implementing Standards

ANSI N18.7/ANS 3.2, Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants, 1976.

ANSI N45.2, Quality Assurance Program Requirements for Nuclear Power Plants.

8.4 Industry Guidance

Guidelines for the Conduct of Operations at Nuclear Power Stations. INPO 01-002, INPO, Atlanta, GA, May 2001. (Available only to INPO members.)

Industry Equipment Reliability Index Estimator, Table A: High Critical Component Failures, ERWG guidance report.

Materials and Services Process Description and Guideline: AP-908, Revision 2. Nuclear Energy Institute, Washington, D.C., 2003.

Nuclear Utility Obsolescence Group (NUOG) Obsolescence Program Guideline, NX-1037, Revision 1. INPO, Atlanta, GA, 2003. (Available only to INPO members.)

Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, NUMARC 93-01, Revision 2, 1993.

Verification Practices—Process Description. INPO AP-931. Atlanta, GA, October 2004. (Available only to INPO members.)

Work Management Process Description. INPO AP-928, Revision 1. INPO, Atlanta, GA, November 2003. (Available only to INPO members.)

8.5 EPRI Reports

Guidelines for Addressing Contingency Spare Parts at Nuclear Power Plants. EPRI, Palo Alto, CA: 2006. 1013472.

Inventory Optimization in Support of the EPRI Work Control Process Module. EPRI, Palo Alto, CA: 1998. TR-109648.

Guidelines for the Technical Evaluation of Replacement Items in Nuclear Power Plants (Revision 1). EPRI, Palo Alto, CA: 2006. 1008256.

Plant Support Engineering: Obsolescence Management. EPRI, Palo Alto, CA: 2008. 1016692.

8.6 Utility Procedures

Critical Spares Determination, Revision 0, SCE&G. Jenkinsville, SC: November 2005. PR-10.

Enhanced Procurement, Revision 4. FirstEnergy Nuclear Operating Company, Akron, OH: February 2007. NOBP-CC-7002.

Enhanced Procurement for Critical Material, Revision 00100. Constellation Nuclear Generation Fleet Administrative Procedure, Constellation Energy, Baltimore, MD: July 2009. CNG-SC-1.01-3000.

Generation Stock Plan—Nuclear, Guidelines for Inventory Optimization, Revision 4. FirstEnergy Nuclear Operating Company, Akron, OH: August 2009.

Integrated Equipment Reliability Strategy Background Information Document—Instrument and Controls. SCE&G, Jenkinsville, SC: 2006.

Station Inventory Optimization, Revision 0, Constellation Energy, Calvert Cliffs Nuclear Power Plant. Lusby, MD: June 2007. PMMG 1-02.

Station Obsolescence Program, Revision 3. SCE&G, Jenkinsville, SC: April 2006. SAP-1287.

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