Obsolescence Management and Reverse Engineering

Basic approaches

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Can obsolescence be eliminated or reversed?

- Some equipment and parts are essentially obsolete by the time a new plant is started-up/commissioned

- Experience indicates that the impact of obsolescence can be managed

“Nuclear” Obsolescence

Supply Chain & Procurement Engineering

Obsolete equipment:

An item in plant service that is no longer manufactured or *is otherwise difficult to procure and qualify*.

(NUOG / INPO NX-1037, Rev. 2)

What causes obsolescence?

- Beyond our control
  - Decreasing demand (diminished motivation to supply)
  - Changes in manufacturing methods and raw materials
  - Discontinuation of nuclear QA programs
  - Mergers and acquisitions

- Within our control
  - Unawareness of factors beyond our control (and resulting failure to take proactive measures)
  - Adversity to design change / modification

- Other
  - Regulatory challenges implementing new technology

What makes obsolescence solutions challenging?

- Regulatory requirements for Design Control (10CFR50, Appendix B)
  - . . . Design changes, including field changes, shall be subject to design control measures commensurate with those applied to the original design and be approved by the organization that performed the original design unless the applicant designates another responsible organization.

- Administrative controls and quality assurance for the operational phase of nuclear power plants (ANSI N18.7)
  - . . . maintenance and modifications affecting the functioning of safety related structures, systems, and components must be "performed in a manner to assure quality at least equivalent to that specified in the original design bases and requirements, material specifications and inspection requirements”

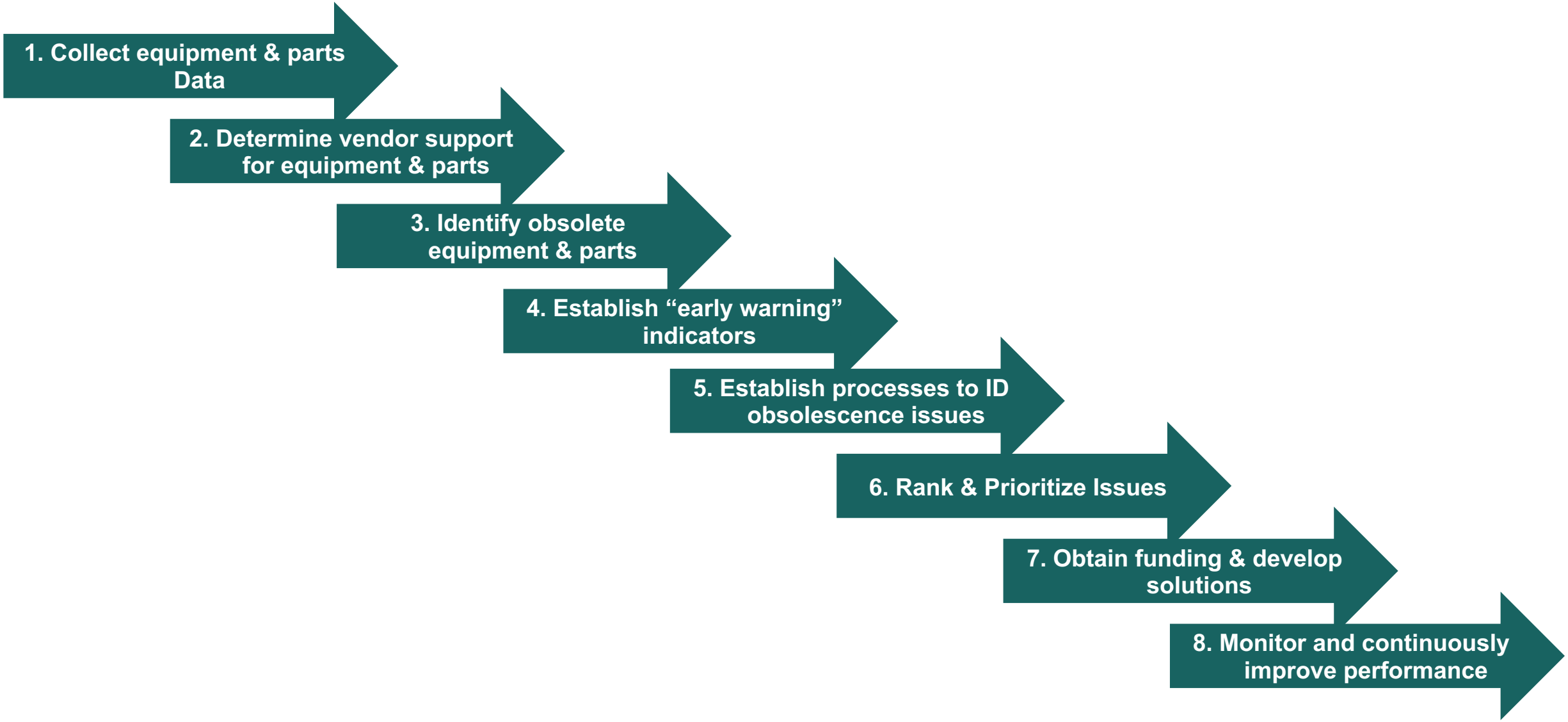
Obsolescence Program Implementation and Lessons Learned

- An approach to managing obsolescence
- Process steps can be incorporated into existing processes and procedures
- Lessons learned
- Precursors to obsolescence
- List of some available tools

Three Basic Elements to Addressing Obsolescence

- Identify Obsolescence Issues
  - An issue may involve multiple parts or equipment
  - Issues can be logically grouped by manufacturer, equipment type, etc.
- Prioritize Obsolescence Issues
  - Equipment Criticality
  - Anticipated need for replacements
  - System Health
- Develop Replacement Solutions
  - Equivalency Evaluations
  - Design Changes
  - Replacement Hardware Solutions

Obsolescence Management Lessons Learned



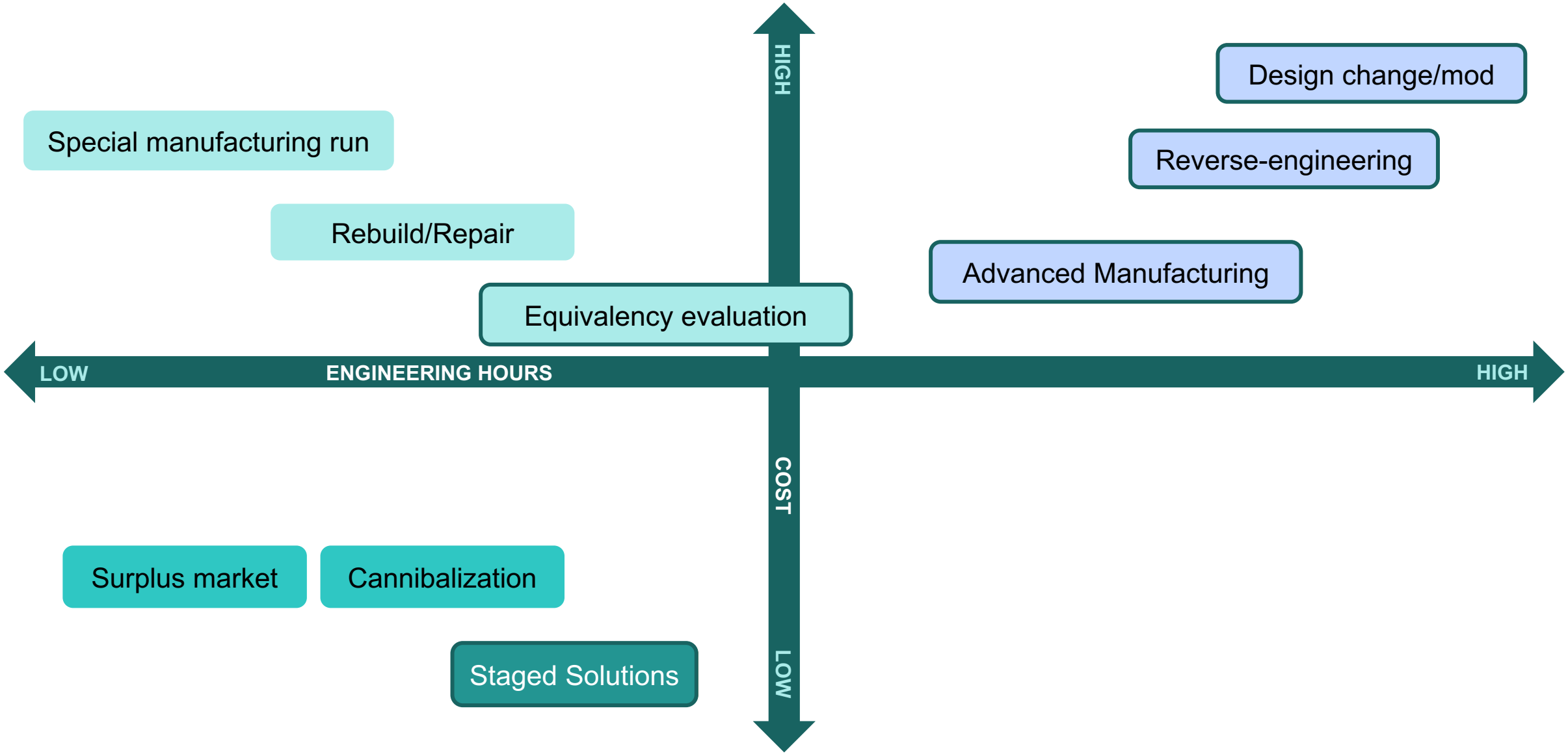
Obsolescence Solutions

Solution	Description
Surplus Markets	Vendors who specialize in the purchase and resale of discontinued items and surplus inventory
Special Manufacturing Run	Original manufacturer tools-up and manufactures a specified quantity of replacement items that meet original requirements
Rebuild / Repair	Programmatic maintenance and upkeep of items that are obsolete, but for which replacement parts can be obtained and repair or rebuild capabilities exist
Cannibalization	Components required to replace obsolete items (or parts required to repair or rebuild obsolete items) are scavenged from identical equipment that is typically no longer in service

Obsolescence Solutions

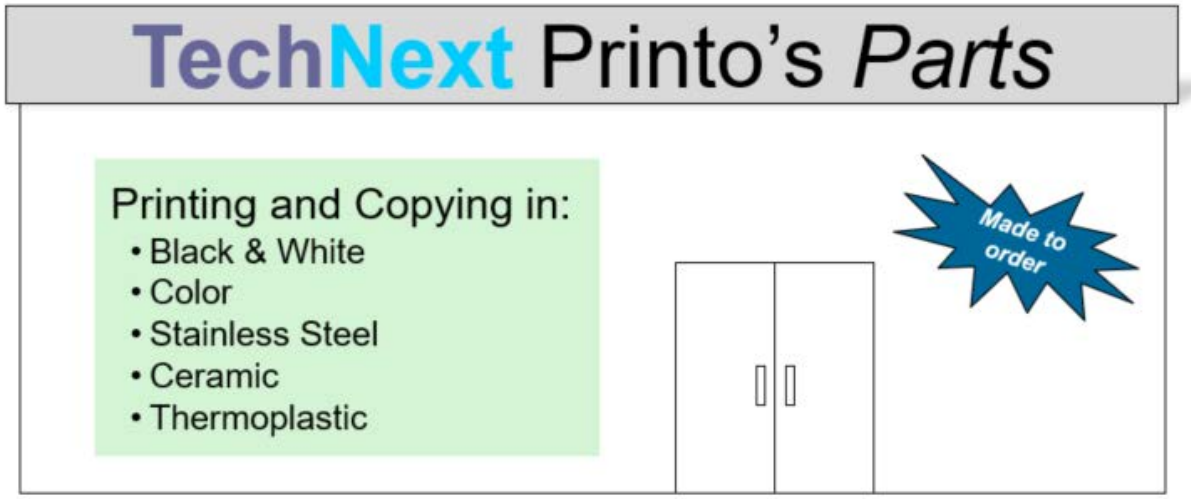
Solution	Description
Substitution	Using an alternate item to replace an obsolete item after applicable requirements have been met (typically, successful equivalency evaluation)
Reverse Engineering	Gathering sufficient information about the design of an obsolete item to successfully manufacture a replacement for the obsolete item (EPRI 3002011678 has more info.)
Design Change	Modification of the facility or equipment (in accordance with all applicable requirements) to allow use of a non-equivalent alternate as a replacement for an obsolete item

Solution Considerations



New Frontiers in managing obsolescence

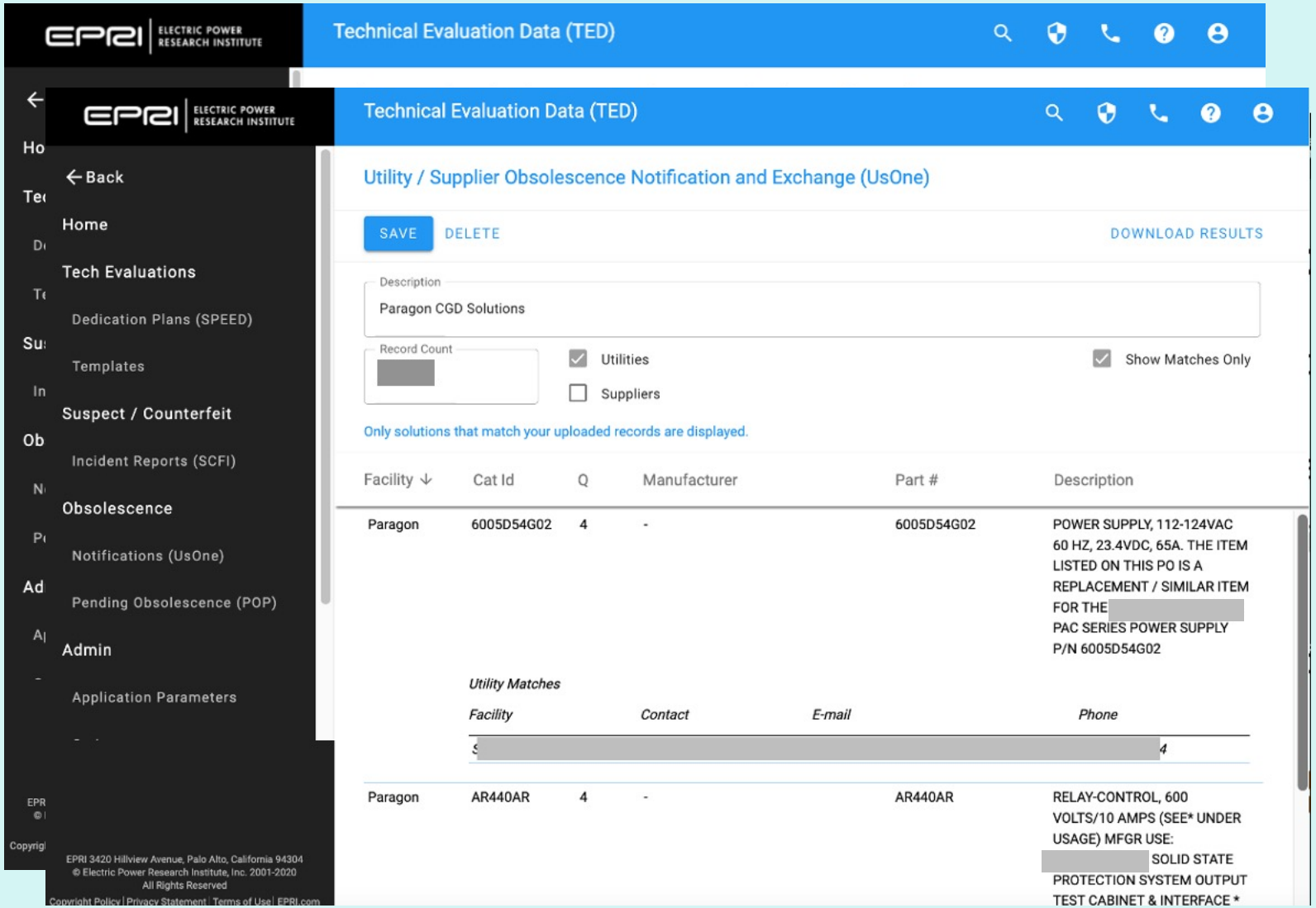
- Advanced Manufacturing
  - Ability to self-manufacture some replacement items
  - Significantly reduced inventory as advanced manufacturing is adopted
- OEM Spares may not be manufactured concurrent with original product
  - Need to update procurement practices and specifications
- "Replacement Item Centers"
  - Access manufacturing "files"
  - Prototype, copy, and print replacement items
- Enhanced ability to share data



Industry Guidance Documents

- International Management of Obsolescence Guidance Document
- INPO NX-1037, Nuclear Utility Obsolescence Group (NUOG) Obsolescence Program Guideline
- EPRI 1019161, Obsolescence Management Program Implementation and Lessons Learned
- EPRI 3002013813, Obsolescence Program Manager Computer-Based training

EPRI Tools - UsOne



Utility/Supplier Obsolescence Notification Exchange

- Suppliers input existing solutions
- Utilities input needed solutions
- Immediate notification of matches
- Collaborative development of future solutions

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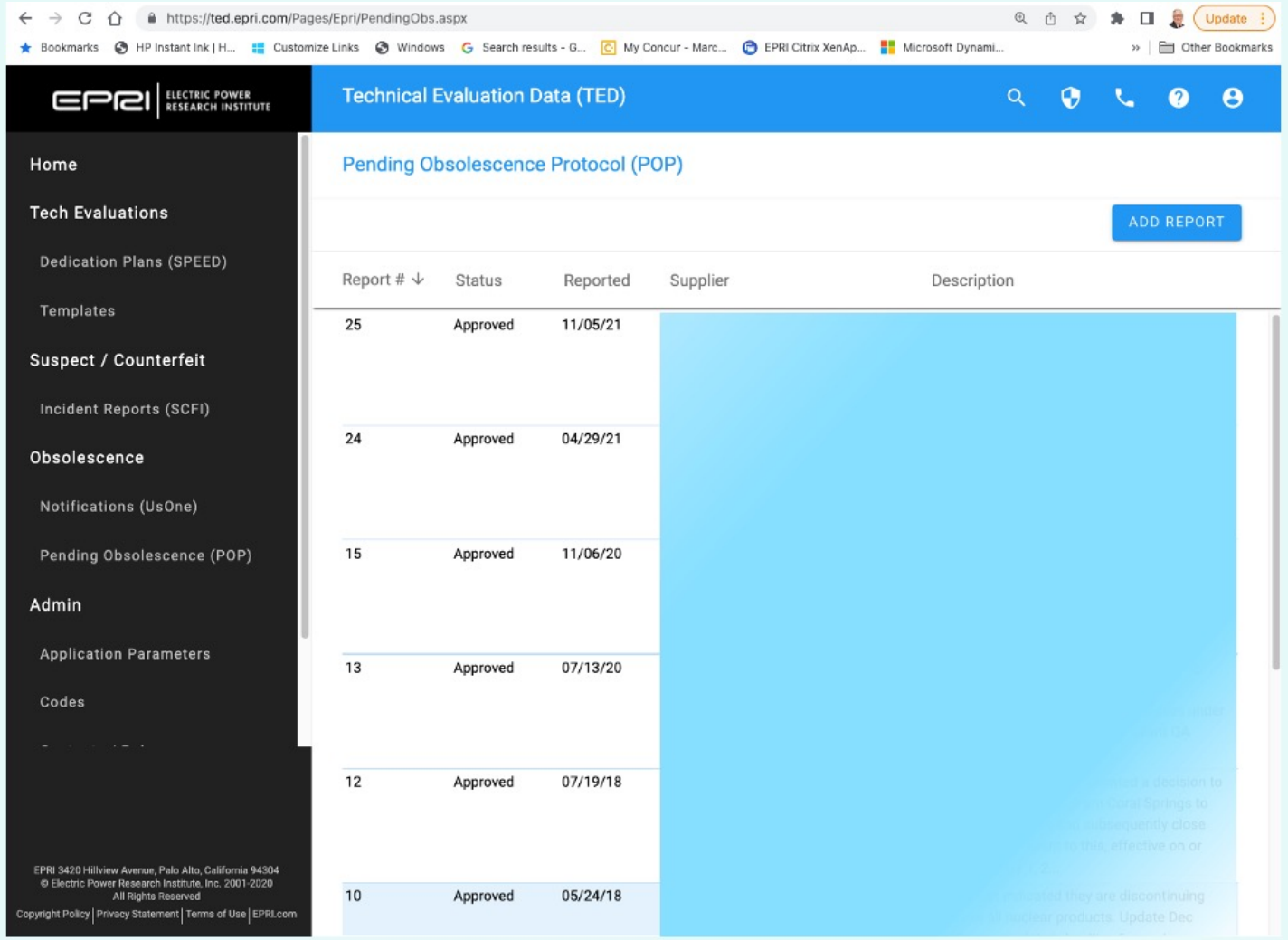
EPRI Tools - POP

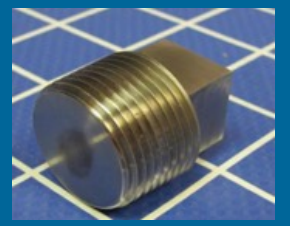
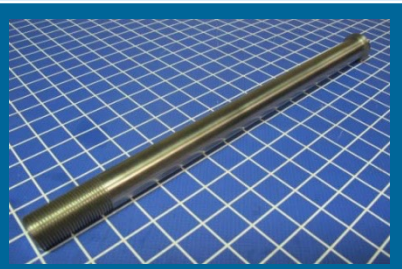
Pending Obsolescence Protocol

- Report and search pending obsolescence issues
- Notify potentially impacted members



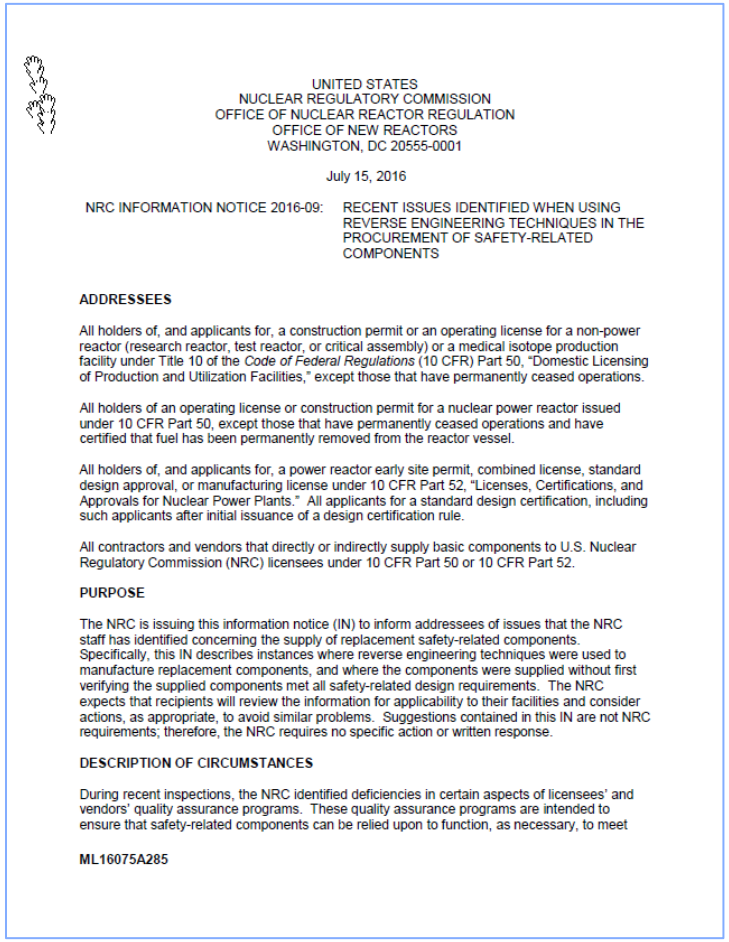
Reverse Engineering

Typical applications of reverse-engineering techniques

Purchasing an item with known attributes or design from a different supplier	
Recover characteristic information for commercial grade dedication	
Produce a functionally equivalent “part’ (simple item)	
Produce a functionally equivalent “component” (complex item)	

Operating experience related to reverse engineering

- NRC Information Notice 2016-09, Recent Issues Identified when Using Reverse Engineering Techniques in the Procurement of Safety-Related Components
  - https://www.nrc.gov/docs/ML1607/ML16075A285.pdf



UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NEW REACTORS
WASHINGTON, DC 20555-0001

July 15, 2016

NRC INFORMATION NOTICE 2016-09: RECENT ISSUES IDENTIFIED WHEN USING REVERSE ENGINEERING TECHNIQUES IN THE PROCUREMENT OF SAFETY-RELATED COMPONENTS

ADDRESSEES

All holders of, and applicants for, a construction permit or an operating license for a non-power reactor (research reactor, test reactor, or critical assembly) or a medical isotope production facility under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those that have permanently ceased operations.

All holders of an operating license or construction permit for a nuclear power reactor issued under 10 CFR Part 50, except those that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

All holders of, and applicants for, a power reactor early site permit, combined license, standard design approval, or manufacturing license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." All applicants for a standard design certification, including such applicants after initial issuance of a design certification rule.

All contractors and vendors that directly or indirectly supply basic components to U.S. Nuclear Regulatory Commission (NRC) licensees under 10 CFR Part 50 or 10 CFR Part 52.

PURPOSE

The NRC is issuing this information notice (IN) to inform addressees of issues that the NRC staff has identified concerning the supply of replacement safety-related components. Specifically, this IN describes instances where reverse engineering techniques were used to manufacture replacement components, and where the components were supplied without first verifying the supplied components met all safety-related design requirements. The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. Suggestions contained in this IN are not NRC requirements; therefore, the NRC requires no specific action or written response.

DESCRIPTION OF CIRCUMSTANCES

During recent inspections, the NRC identified deficiencies in certain aspects of licensees' and vendors' quality assurance programs. These quality assurance programs are intended to ensure that safety-related components can be relied upon to function, as necessary, to meet

ML16075A285

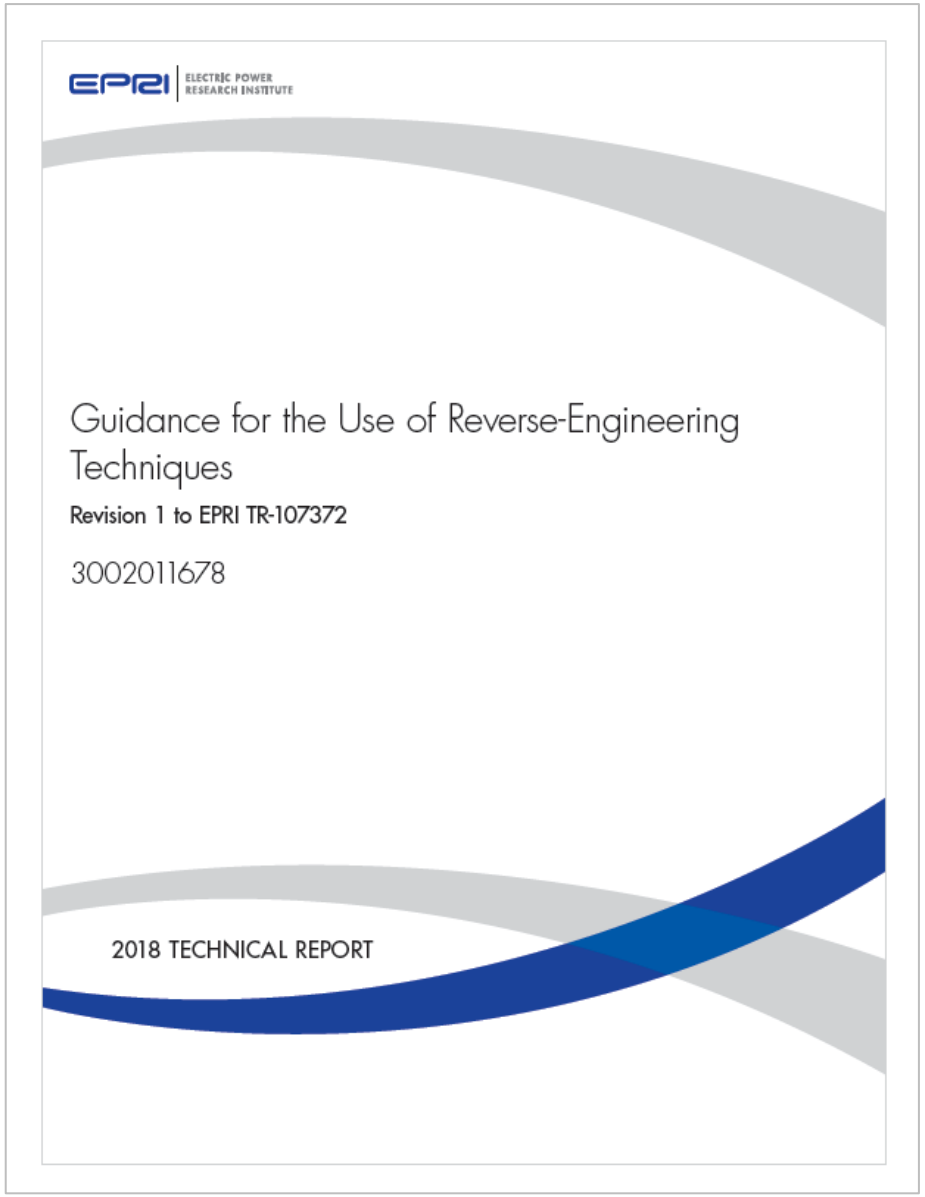
NRC Information Notice 2016-09

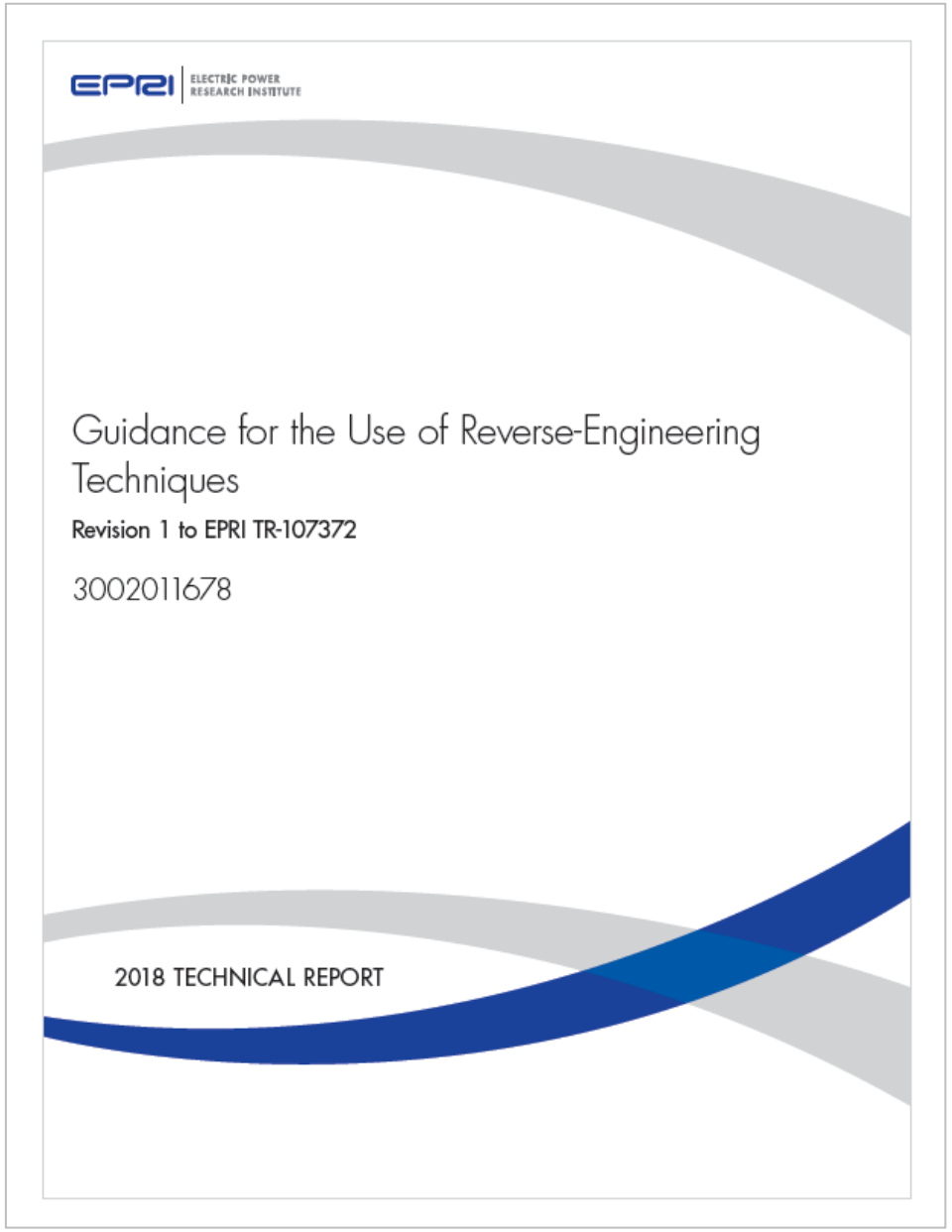
- *". . . reverse-engineering techniques were used to manufacture replacement components . . . where the components were supplied without first verifying the supplied components met all safety-related design requirements."*

- NRC inspectors identified the following issues associated with the procurement of reverse engineered components:
  - not developing a full understanding of design requirements
  - assuming that a reverse-engineered component is identical to the original equipment manufacturer (OEM) component even though it was not subject to the same design and manufacturing specifications and processes as the original component
  - assessing only the physical attributes of the component without properly evaluating functional design requirements
  - not passing on all relevant design requirements to the supplier
  - not verifying that all safety-related design requirements have been met, either by testing or analysis

Significant concepts in the updated EPRI guidance

- Use of reverse engineering techniques involves:
  - Understanding of design functions
  - Understanding in-situ conditions
  - Understanding interface requirements
  - Measures to ensure design is controlled
- Communication is critical
  - Licensee must provide appropriate information

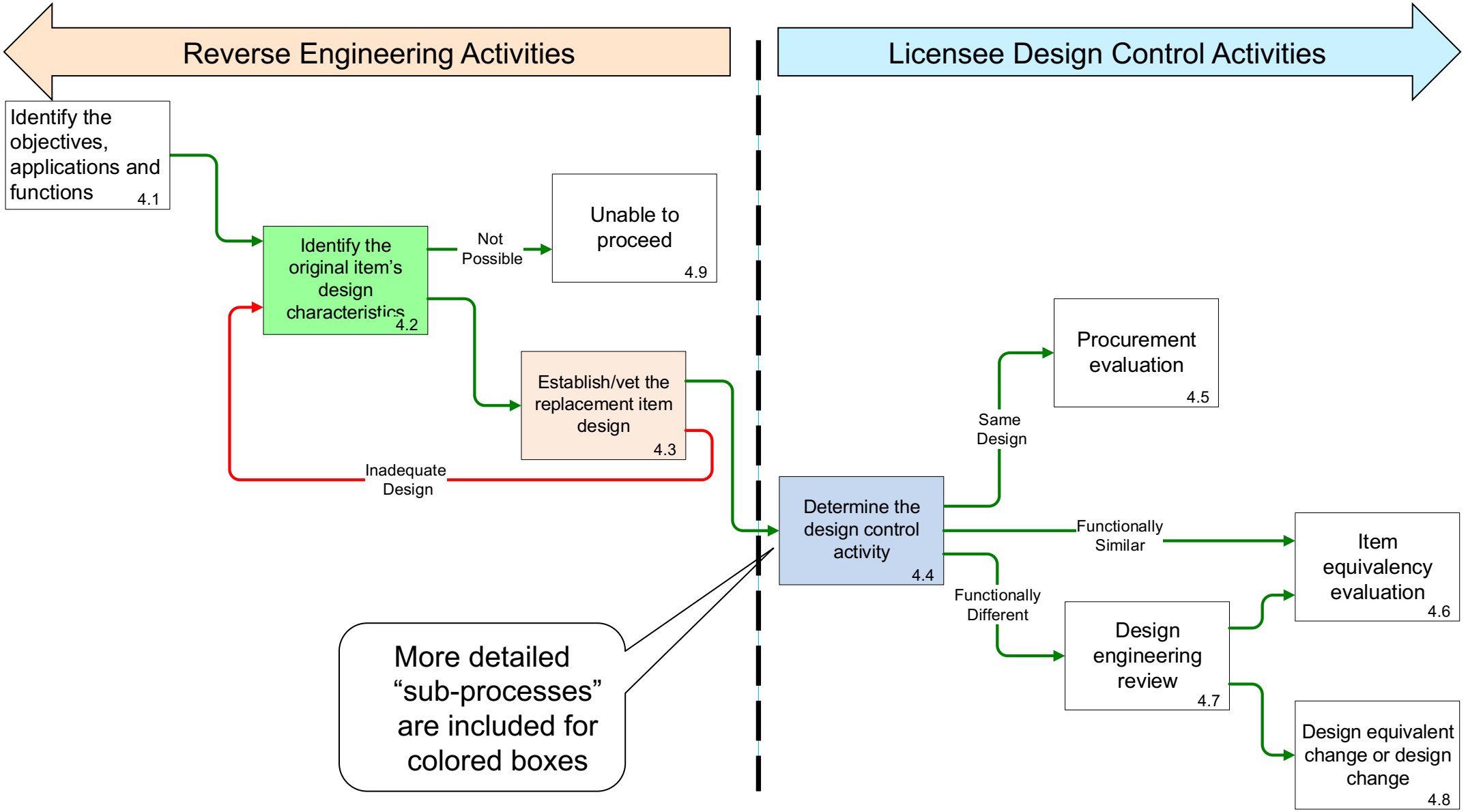




Significant concepts in the updated guidance

- Reverse engineered replacement items are subject to the same design control measures as other replacement items
  - Do not assume a reverse engineered item is identical or equivalent to the original item
- Risk is inherent when reverse-engineering techniques are applied

Basic process for applying reverse-engineering techniques



1. Identifying Objectives - Communication between licensee and RE entity

- Initial exchange of information and objectives
  - Objective/Purpose of RE
  - Type of item
  - Availability and condition of specimens
  - Availability and condition of interfacing items
  - Types of testing and examination anticipated
  - Equipment qualification requirements



- Interface plan
  - Early and often
- Reverse-Engineering output
  - Bills of Material
  - Procurement documents for sub-tier suppliers
  - Supplier assessment results/reports
  - Qualification test records
  - Component-level specifications
  - Prototype test results
  - Certification

Project Initiation Form

Reverse Engineering Project Initiation Form — EPRI Joint Utility Task Group
Form RE1, Rev. 0

SECTION A CONTACT INFORMATION

CUSTOMER BUSINESS CONTACT, EMAIL, PHONE:	CUSTOMER TECHNICAL CONTACT, EMAIL, PHONE:
SUPPLIER BUSINESS CONTACT, EMAIL, PHONE:	SUPPLIER TECHNICAL CONTACT, EMAIL, PHONE:

SECTION B ITEM IDENTIFICATION

INVENTORY CONTROL NO:	
NOUN IDENTIFIER:	
DESCRIPTION:	
ORIGINAL MANUFACTURER NAME:	MANUFACTURER MODEL / PART / CATALOG NUMBER(S)
ORIGINAL SUPPLIER NAME (IF DIFFERENT):	SUPPLIER MODEL / PART / CATALOG NUMBER(S)

SECTION C ITEM INFORMATION

PRODUCTION STATUS:
Is the item obsolete? ☒ Yes ☐ No

EQUIPMENT ID (TAG) NUMBERS OR DESCRIPTION OF ITEM USAGE:

PARENT COMPONENT/HOST DESCRIPTION:

FUNCTIONAL SAFETY CLASS OF ITEM:	BASIS / SOURCE:
☒ Safety-Related ☐ Non-Safety Related	

DESCRIPTION OF ITEM FUNCTION

IMPACT ON FUNCTION OF HOST COMPONENT / SYSTEM

SPECIAL REQUIREMENTS (CHECK ALL THAT APPLY):

☐ EQ	☐ ASME SECTION III
☐ CLASS 1E	☐ CONTAINMENT PRESSURE BOUNDARY
☒ SEISMIC CLASS 1	☐ SERVICE LEVEL 1 COATING
☐ OTHER: (see below)	

Reverse Engineering Project Initiation Form — EPRI Joint Utility Task Group
Form RE1, Rev. 0

SECTION D AVAILABLE INFORMATION

AVAILABILITY OF SPECIMEN(S):	CONDITION OF SPECIMEN(S):
☐ A single specimen is available	Is specimen new or used? ☐ New ☐ Used
☐ Multiple specimens are available	Is the specimen contaminated? ☐ Yes ☐ No
☐ No specimens are available	Can the specimen be destroyed? ☐ Yes ☐ No
AVAILABILITY OF INTERFACING ITEMS:	**CONDITION OF INTERFACING ITEMS:**
☐ All interfacing items are available	Are items new or used? ☐ New ☐ Used
☐ Some interfacing items available	Are items contaminated? ☐ Yes ☐ No
☐ No interfacing items available	Can the items be destroyed? ☐ Yes ☐ No

COMMENTS RELATED TO SPECIMEN AND INTERFACING ITEMS:

AVAILABLE DRAWINGS AND DOCUMENTS:

KNOWN ITEM CHARACTERISTICS:

AVAILABLE OPERATING EXPERIENCE:

CORRECTIVE ACTION / MAINTENANCE FEEDBACK / HISTORY (THAT WOULD SUGGEST ENHANCEMENTS)

IN-SITU CONDITIONS / ENVIRONMENTAL REQUIREMENTS

Reverse Engineering Project Initiation Form — EPRI Joint Utility Task Group
Form RE1, Rev. 0

SECTION E SUPPLIER INFORMATION

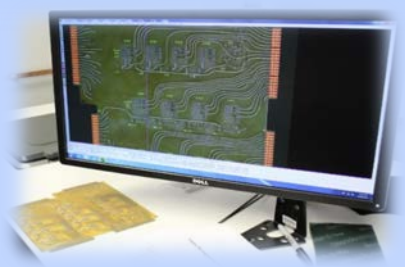
REVERSE ENGINEERING TECHNIQUES WILL BE USED TO:

- ☐ Obtain information necessary to enable procurement from an alternate source
- ☐ Recover information to develop a design for a replacement item used for a specific application
- ☐ Recover information to develop a design for a replacement item that can be used as a generic replacement in many applications
- ☐ Recover characteristic information for use in commercial grade dedication
- ☐ Other (describe below)

TESTING AND EXAMINATION ANTICIPATED:

	Type of Test / Examination	Type of Equipment	
☐	Chemistry		
☐	Hardness		
☐	Tensile		
☐	Yield		
☐	Plating type & thickness		
☐	Heat treatment		
☐	Dimensions		
☐	Circuit analysis		

2. Identify the original item's design characteristics



- Use all available sources of design information
  - Original equipment manufacturer
  - Original equipment manufacturer sub-tiers
  - Nuclear Steam System Supplier
  - Licensee
  - Architect Engineer or Engineering, Procurement Construction
- Examine specimens of original item using measurement, functional testing, material testing and analysis
  - Multiple specimens if available
  - If specimens are used, account for wear

- New technologies
  - Laser and structured light scanning
  - Circuit card analysis
- Review of operating experience
- Incorporate any needed enhancements
- Account for environmental conditions
- Account for interfaces, fits and tolerances

3. Establish/Vet replacement item design

- Recovered design information is vetted to identify, address, and document any gaps or assumptions
  - Unknown design parameters, interfaces, adequacy of tolerances
- Are design functions understood and accounted for in the RE design?
- Are in-situ conditions known and accounted for?
  - Undervoltage/overvoltage, temperature, environment, etc.
- Have interfaces with other equipment been considered?
  - Could the RE design impact successful interface?
- Have unknown parameters been identified and resolved?

- If unable to determine some aspects of the design:
  - Document any assumptions made about the RE design or
  - Establish generic boundaries for the RE design and verify suitability of design for the generic boundaries
- Develop a plan to verify function of the RE device and establish confidence that the item can perform its design functions under its in-situ conditions and environment
- Determine if planned activities are sufficient to establish suitability of the RE design in light of available information
- Complete activities necessary to verify functionality and if successful, finalize the RE design

Requirements Matrix

Reverse-Engineering Requirements Matrix — **EPRI Joint Utility Task Group**
Form RE2, Rev. 0

Requirements Matrix

NO.	REFERENCE NUMBER	EXACT WORDING OF REQUIREMENT/DESIGN INPUT FROM TECHNICAL SPECIFICATION/REFERENCE	REQUIREMENT CATEGORY	CLASSIFICATION	SOURCE DOCUMENT NAME, SECTION, AND PAGE NUMBER	NOTES	MOST RESTRICTIVE (WORST CASE) APPLICATION	VERIFICATION	VALIDATION
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)

COMMENTS

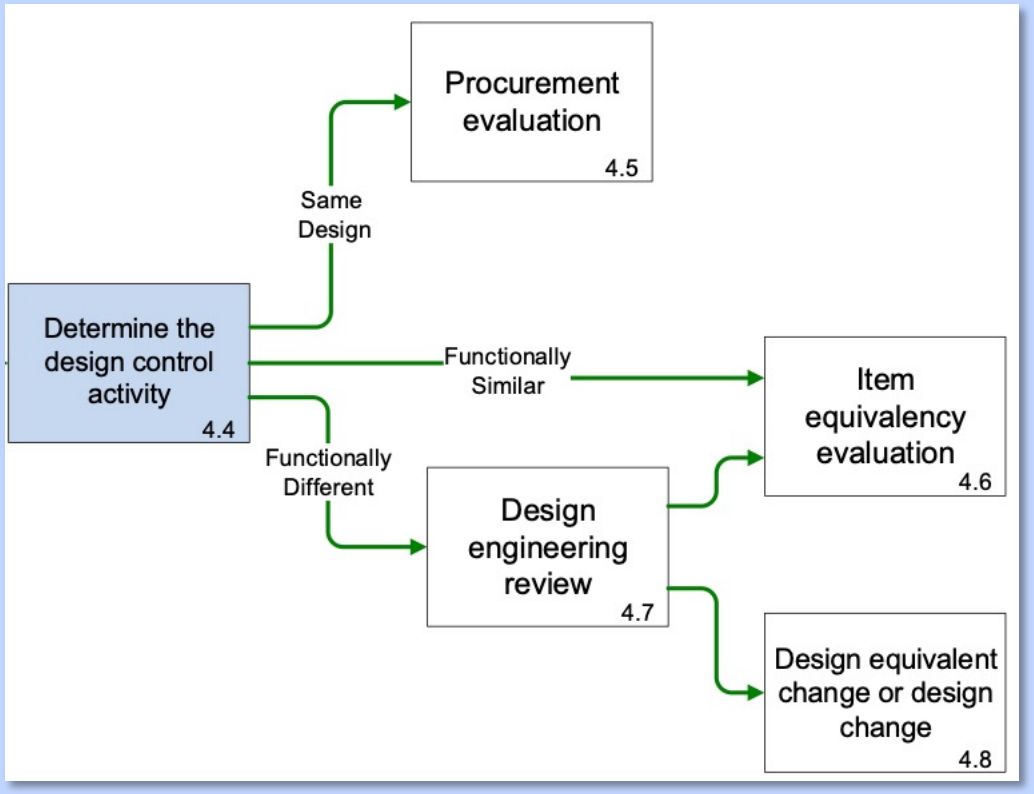
Approvals:

_____ Preparer _____ Date

_____ Reviewer _____ Date

_____ Quality Assurance _____ Date

4. Determine the design control activity



- Items obtained through use of reverse engineering techniques are subject to the same design control measures as other replacement items
- A replacement item design recovered through use of reverse engineering techniques may not be assumed to be identical or equivalent to the original item

Customer and Supplier Responsibilities

Design information	Scenario	Customer Responsibilities	Supplier Responsibilities	Plans to market as an "aftermarket" basic component replacement
Item Design is Known	Customer provides complete design information Manufactured to industry standard	Customer provides complete design Customer maintains design control (procurement evaluation, equivalency evaluation, design equivalent change or design change)	Supplier does no design work Supplier manufactures to customer design Supplier certifies to customer design	Supplier publishes product capabilities / specifications Supplier verifies suitability of design for published capabilities (testing, design review, alternate calculations)
Item Design is Unknown	Customer provides working / non-working specimen and/or specimen purchased from alternate source Customer provides quality and technical requirements / equipment specification	Customer verifies supplier is approved to provide reverse engineering services Design responsibility is addressed in the purchase order Customer Engineering approves design Customer maintains design control (equivalency evaluation, design equivalent change or design change) Customer provides applicable interface requirements	Supplier recovers design information Supplier verifies suitability of design for identified functions (testing, design review, alternate calculations) Supplier submits design to customer for approval	Same as above

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