EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Reverse-Engineering

EPRI 3002100678

Updated Guidance

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Cleveland, Ohio
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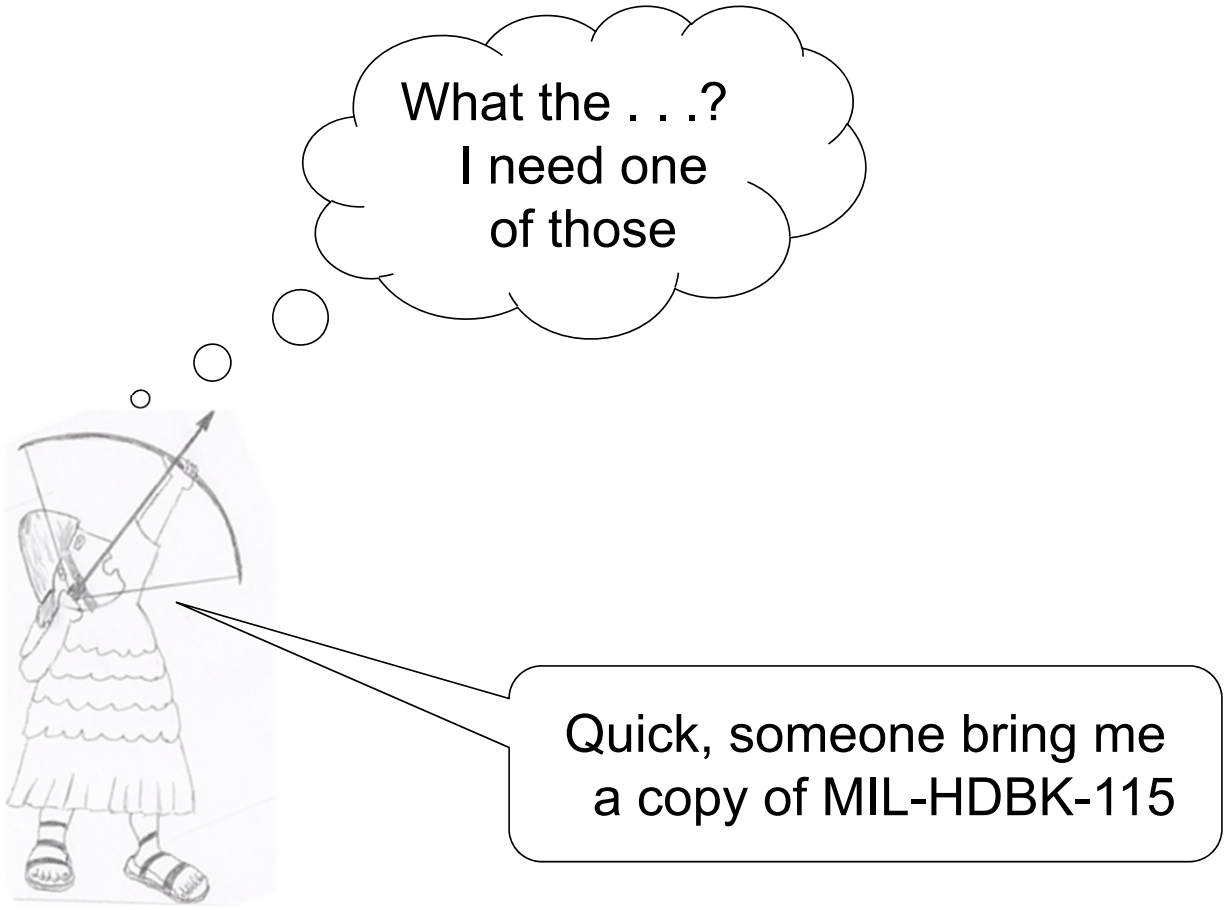
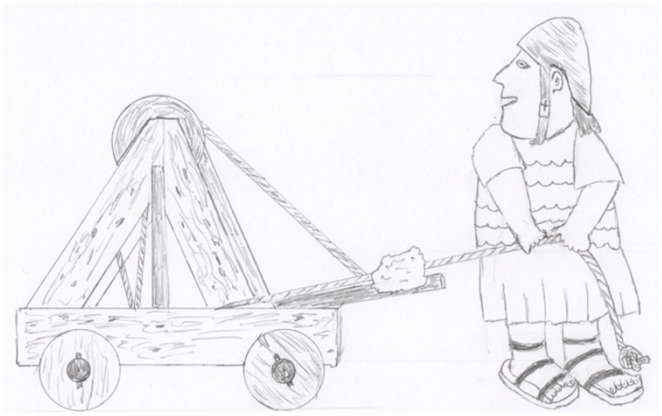
What are reverse-engineering techniques?

- Reverse-engineering techniques involve examining an existing specimen as well as review and analysis of information available about the item's design and its design functions to enable manufacturing or otherwise facilitate acquisition of the item

- Reverse-engineering techniques are typically applied in situations where complete original design information is not available

Is this a new concept?





Why would a nuclear power plant want to apply reverse-engineering techniques?

- Facilitate obtaining replacement parts and equipment
  - Develop information necessary to accurately specify an item for subsequent procurements
  - Develop acceptance criteria for commercial grade item dedication
  - Facilitate fabrication of equivalent replacement items

- Application of reverse-engineering techniques is one of the most powerful tools available to mitigate the impact of aging and obsolete equipment

Why would a supplier want to apply reverse-engineering techniques?

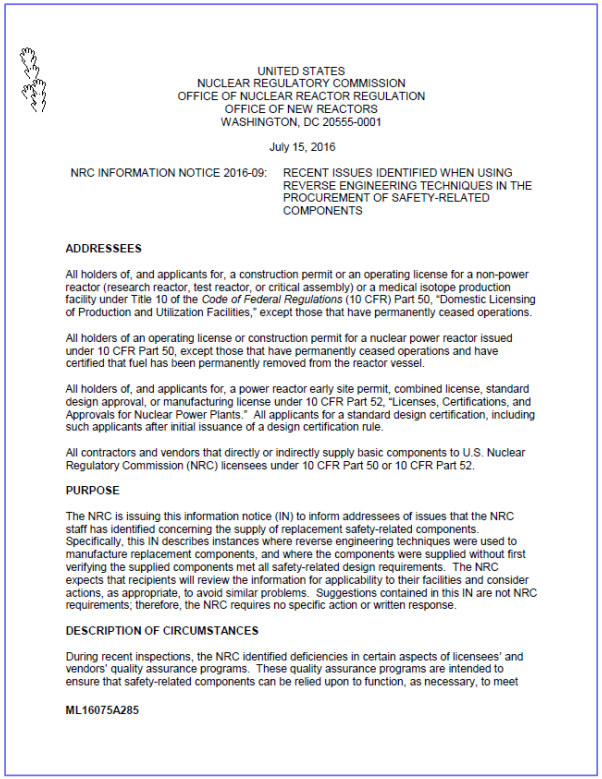
- Support their customers
  - Facilitate fabrication of an equivalent replacement item for one customer
  - Facilitate fabrication of an “aftermarket” replacement item that may be needed by several customers
    - When marketing an item as a “generic” replacement, the supplier must verify suitability of design for their published product capabilities/specifications.
      - Testing
      - Design review
      - Alternate calculations

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, and 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

Impetus for reverse-engineering Guidance Revision

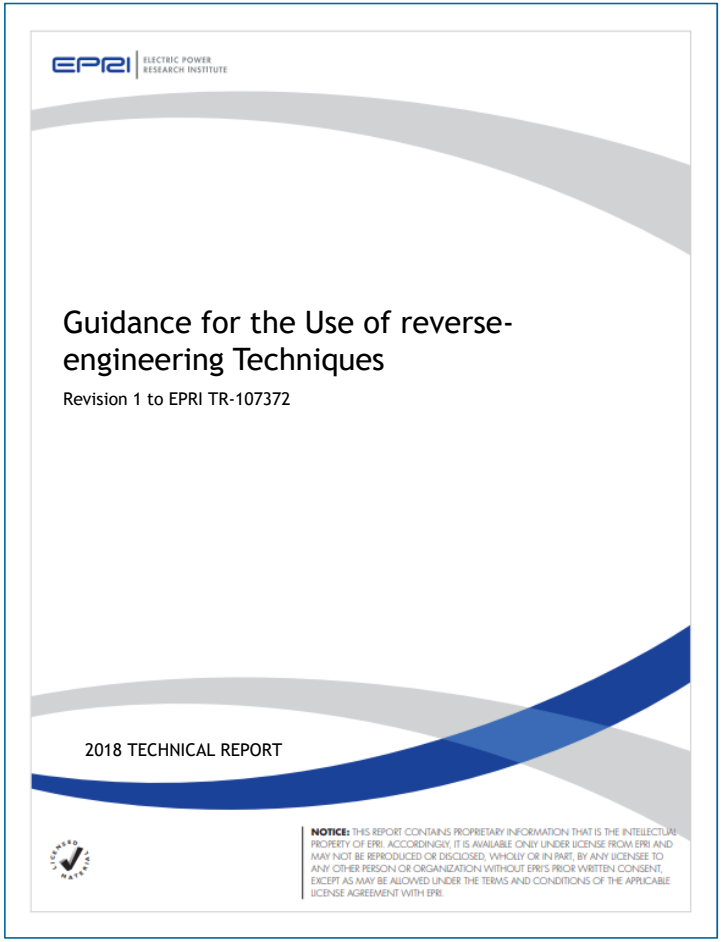
- Original RE Guidance addressed “how to” reverse engineer from a licensee’s perspective
- Original RE Guidance did not include detail on options for suppliers or licensees to accept a reverse engineered item for use (control design)
- NRC inspections identified that assuming that an item is equivalent simply because it was reverse engineered is not acceptable from a regulatory perspective

Reverse-Engineering guidance update team

Reverse-Engineering guidance preview team

Significant concepts in the updated guidance

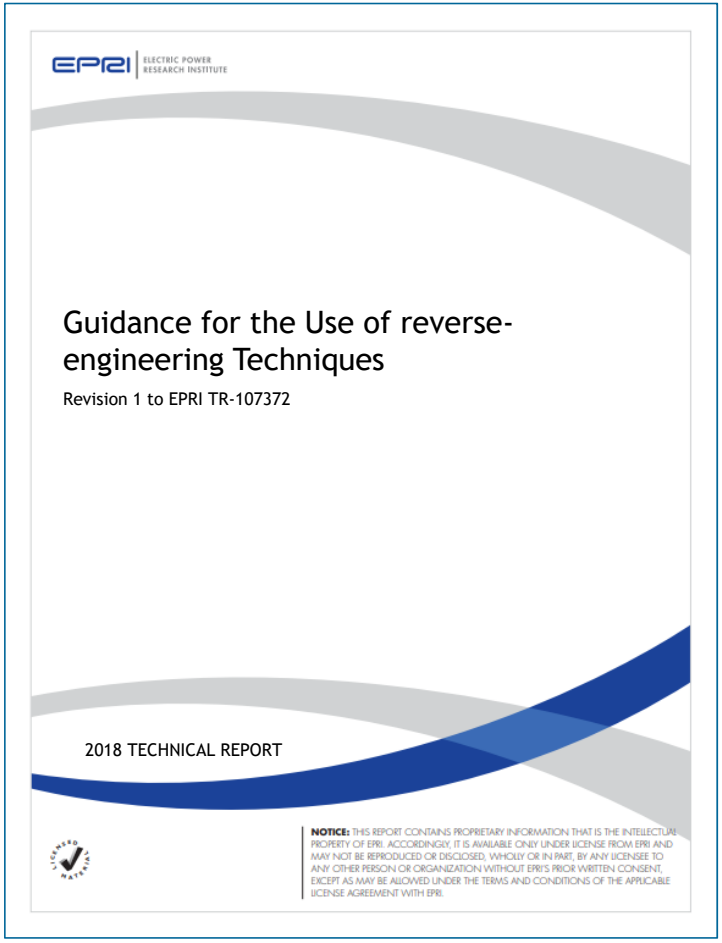
- Use of reverse-engineering techniques involves:
  - Understanding of design functions
  - Understanding in situ conditions
  - Understanding interface requirements
  - Measures to ensure design is controlled
- Communication is critical
  - Licensee must provide appropriate information



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

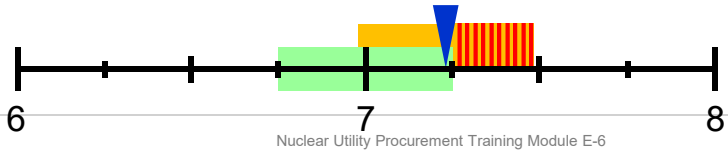


Risk factors

- An aspect of the original design could be overlooked or incorrectly interpreted
- Risk of unsuccessful outcome
- Limitations of physical examination (complex, active function)

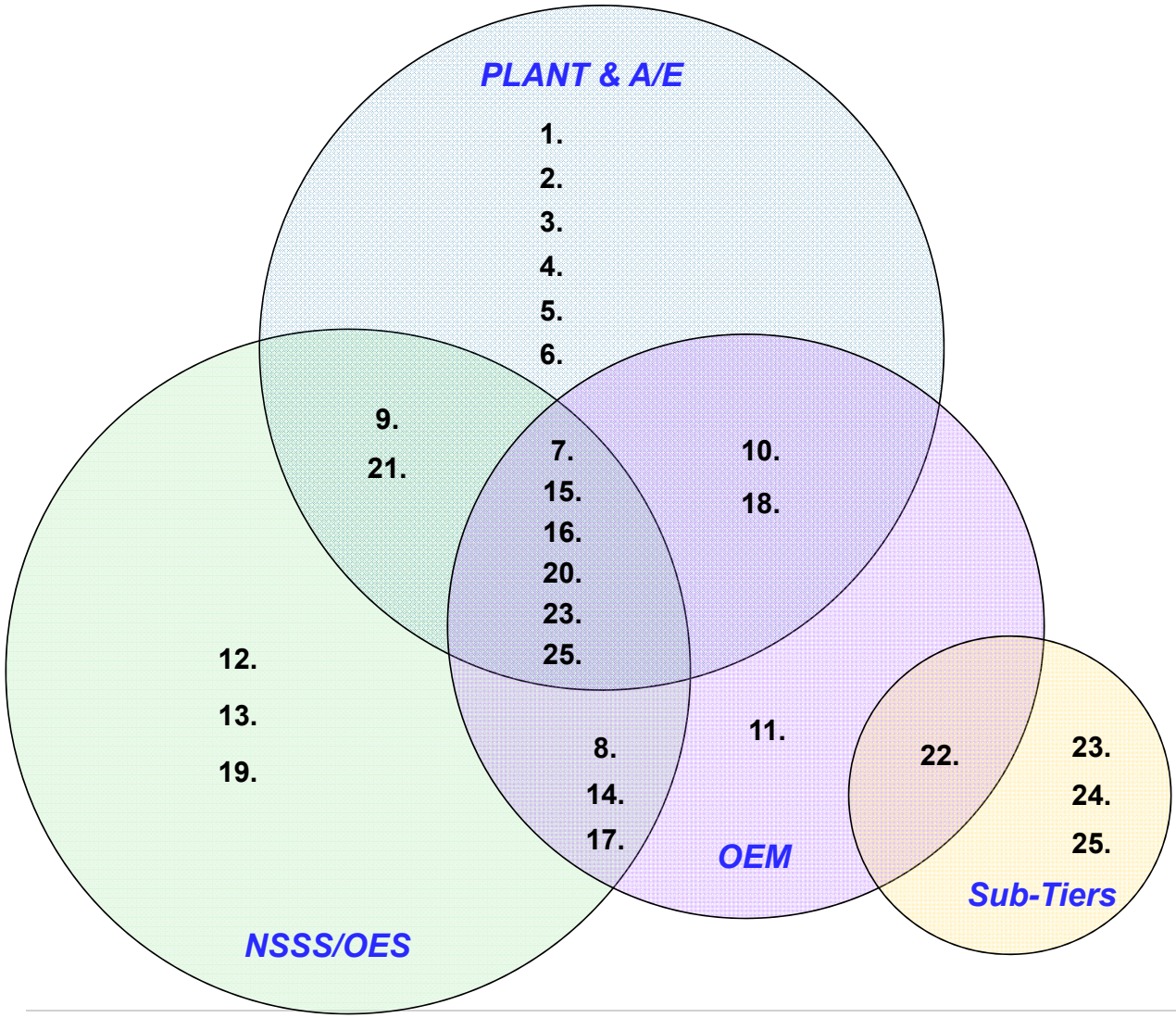
Measured from Sample:	7.23
Tolerance based on machining process:	+/- 0.25
RE Design Requirement / Tolerance:	6.98 - 7.48
Unknown that OEM Requirement / Tolerance was 7+/- 0.25	6.75 - 7.25

Could there be a problem?



Risk also depends upon available design information

- The “level of detail” of design information originally provided to the licensee (and currently available) varies
  - Items originally procured by the NSSS
  - Items originally procured by the Architect/Engineer
  - Items originally procured by the construction company (EPC)
  - Items originally procured by the licensee
  - Items originally procured by the OEM



1. FSAR
2. Licensing documents
3. Operating experience
4. System performance/monitoring info
5. End use applications
6. In situ conditions
7. Non-NSSS original equipment PO and specifications
8. NSSS original equipment PO & specifications
9. NSSS system descriptions
10. Equipment outline drawings/BOMs
11. Equipment manufacturing information
12. NSSS design requirements
13. Proprietary system integration information
14. NSSS OEM identity
15. Original design requirements and acceptance criteria
16. Construction system-level specifications
17. NSSS system interface requirements
18. Product-specific design experience
19. NSSS interface requirements
20. ASME design specification
21. Certified reactor plant design
22. Subassembly outline drawings/BOMs
23. Subassembly/Part design
24. Subassembly/Part manufacturing information
25. Industry standards (all entities)

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
- 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)	

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Form RE1, Rev. 0

SECTION D AVAILABLE INFORMATION

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

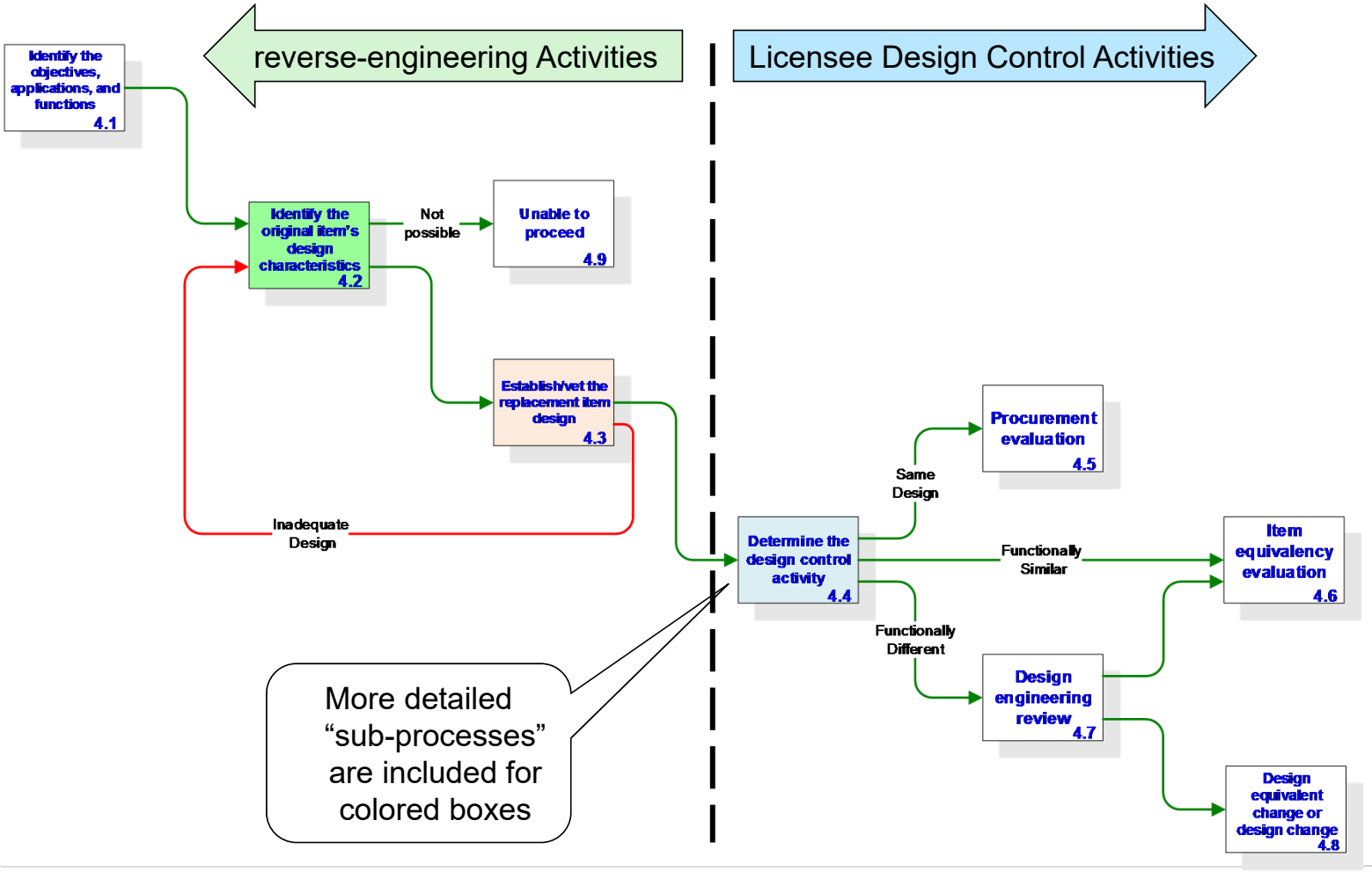
Reverse Engineering Project Initiation Form — EPRI Joint Utility Task Group
Form RE1, Rev. 0

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		

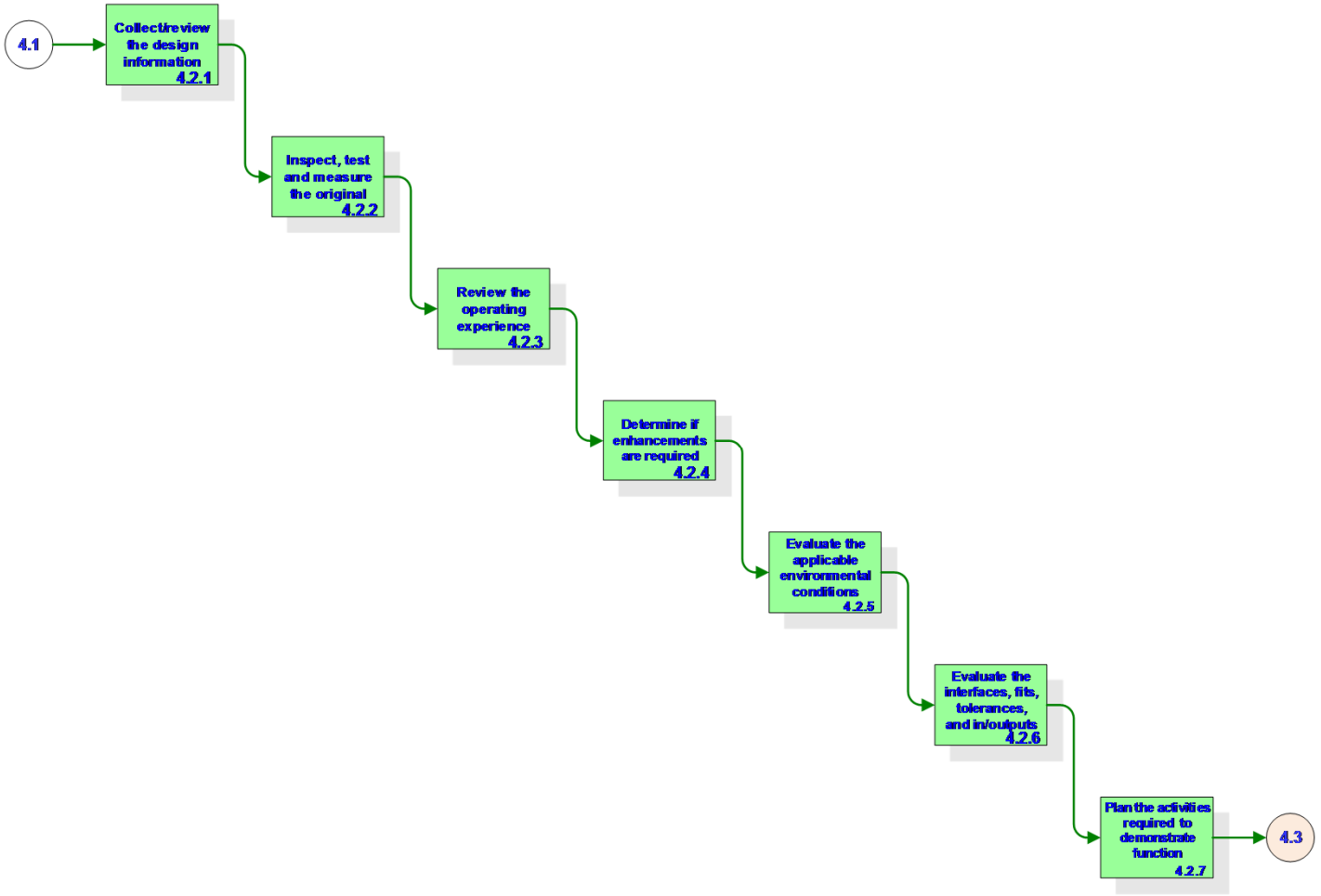
Basic process for applying of reverse-engineering techniques



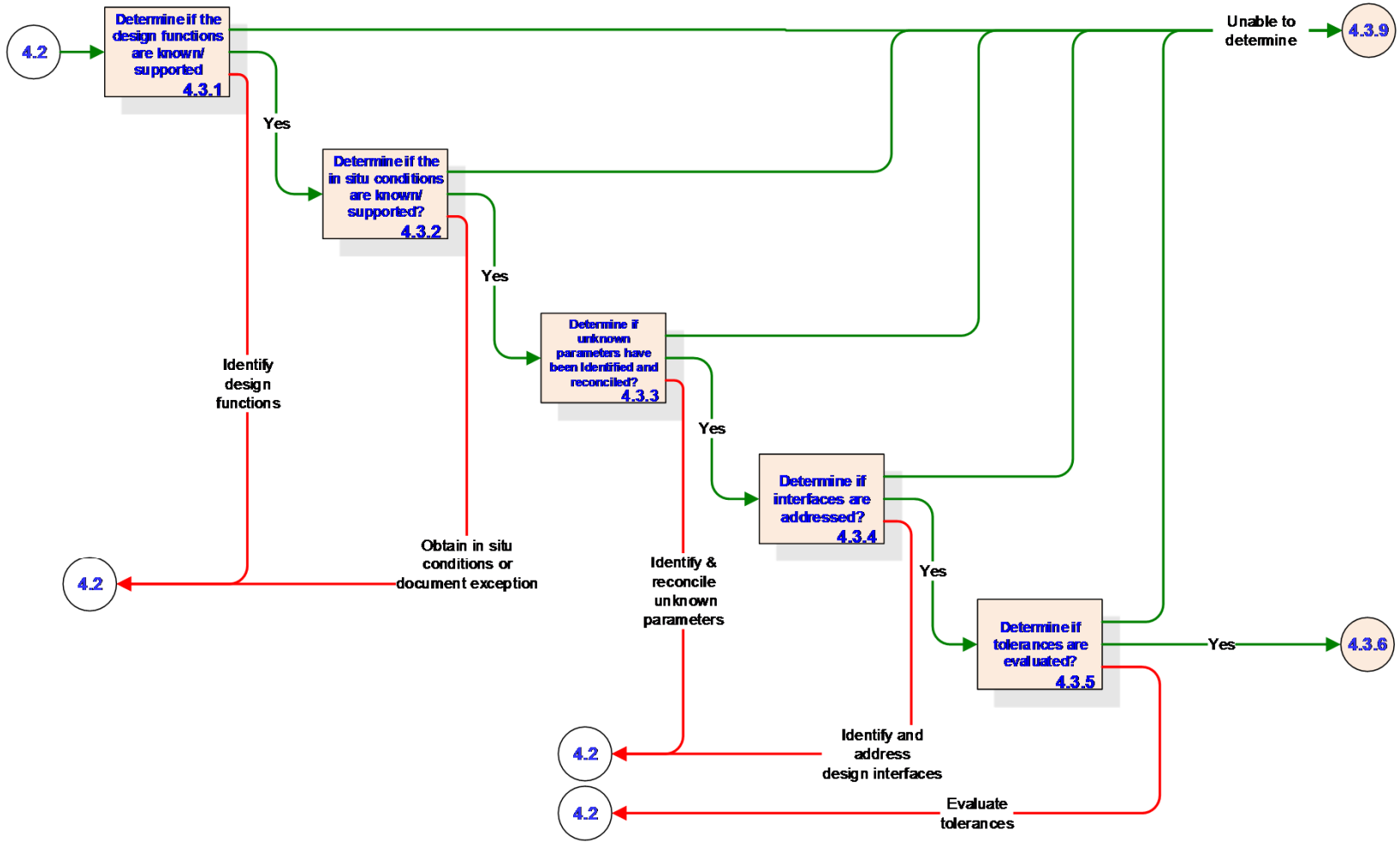
Basic RE Process – Selection of appropriate design control

- Procurement evaluation (procurement engineering)
  - Documents changes to procurement information such as description, specifications, technical and quality requirements
- Item equivalency evaluation (procurement engineering)
  - Establishes the design of a RE replacement item is equivalent to the original item
- Design equivalent change (design engineering)
  - Design qualifications are necessary to conclude the RE item is within bounding technical requirements
- Design change (design engineering)
  - RE item is outside of the bounding technical requirements for the original item

Application of reverse-engineering techniques



Evaluate confidence in design



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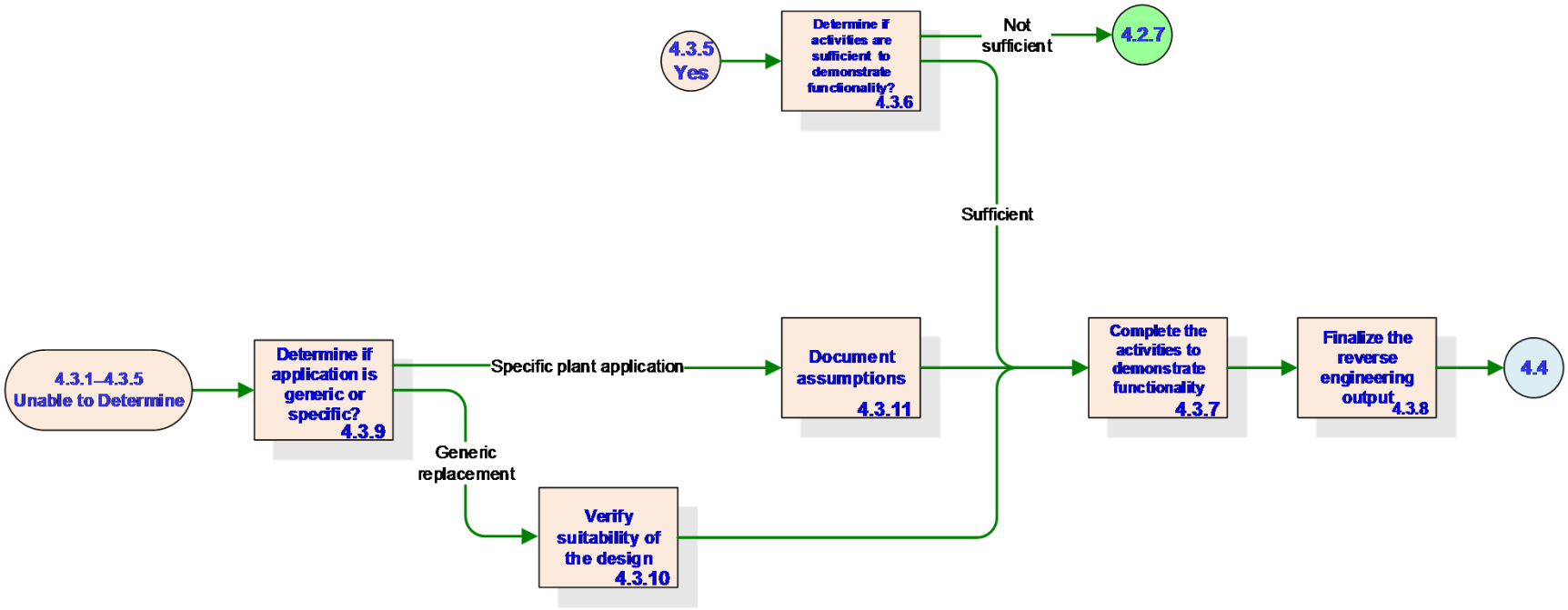
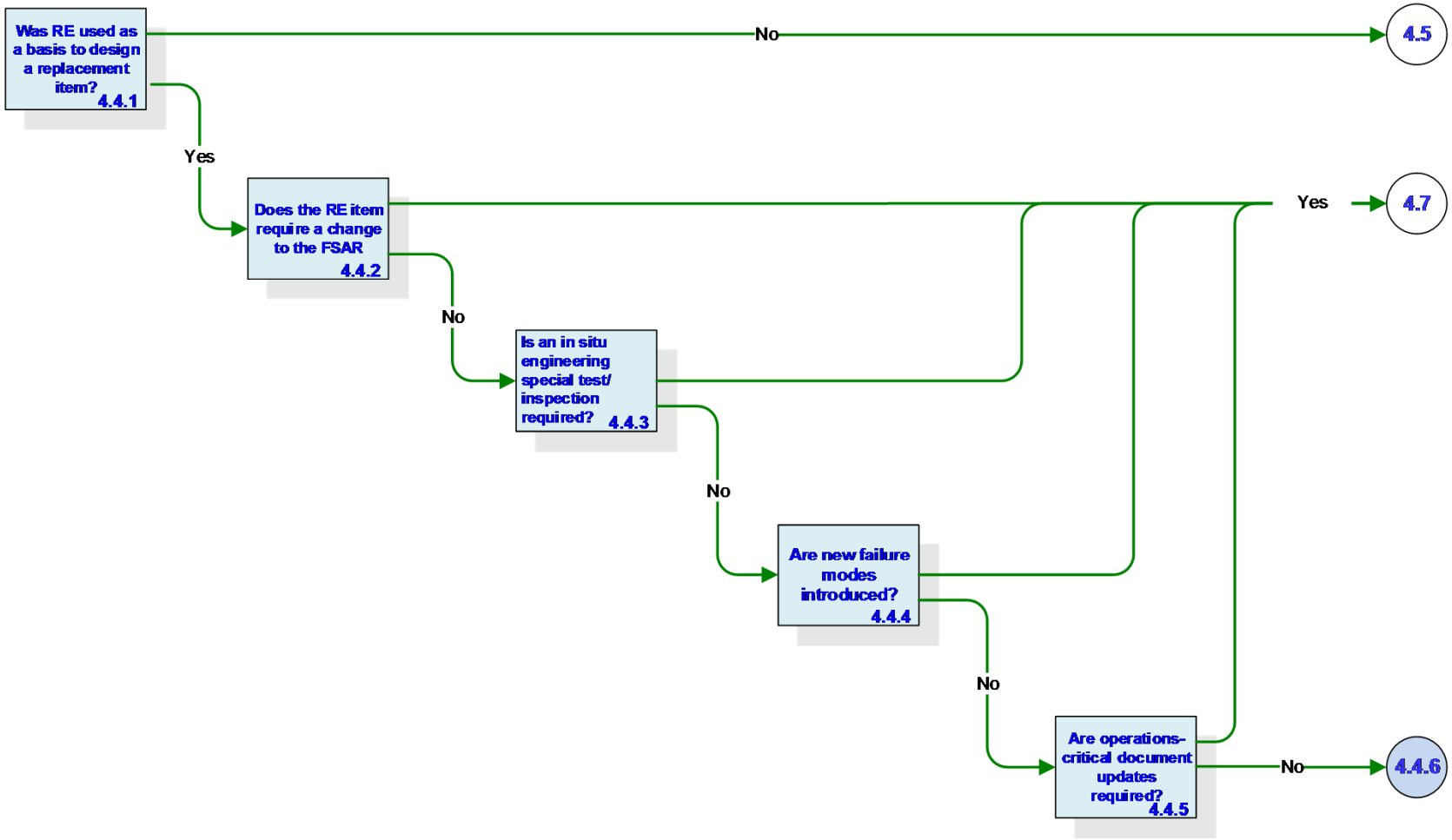


Determine design control process



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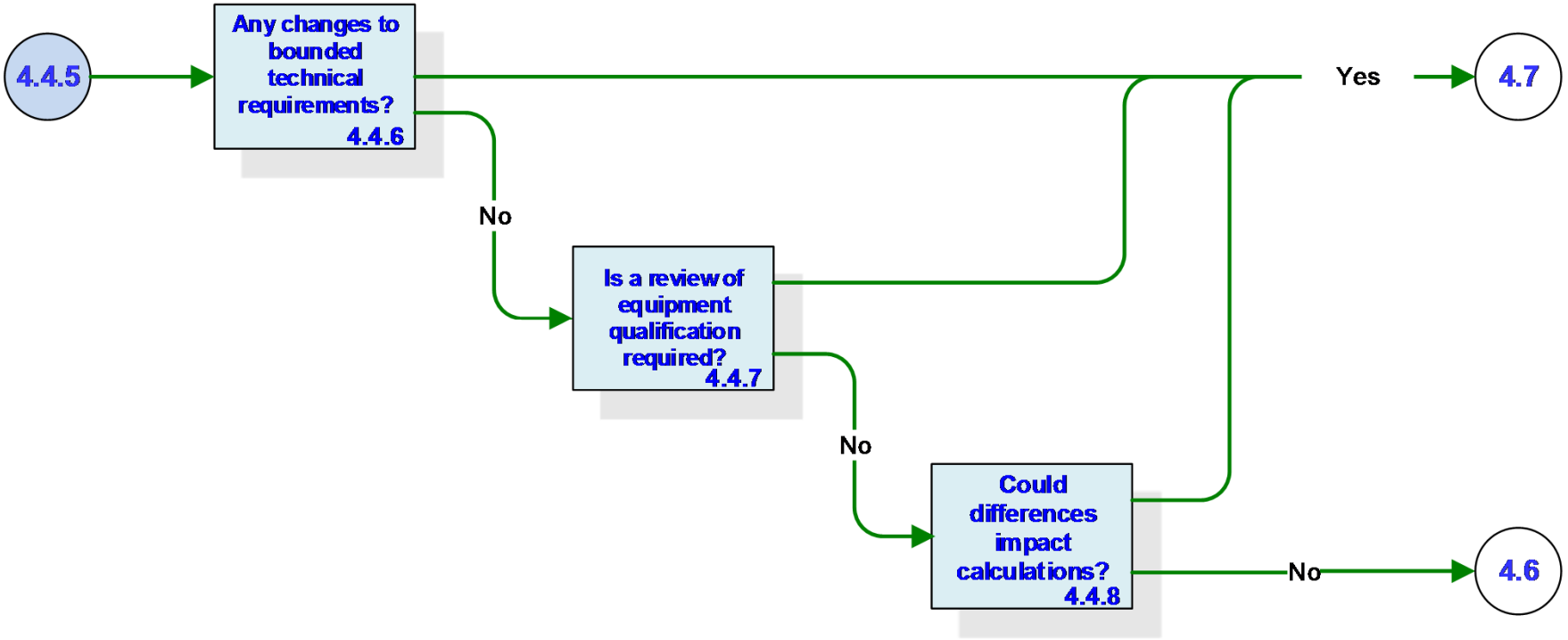
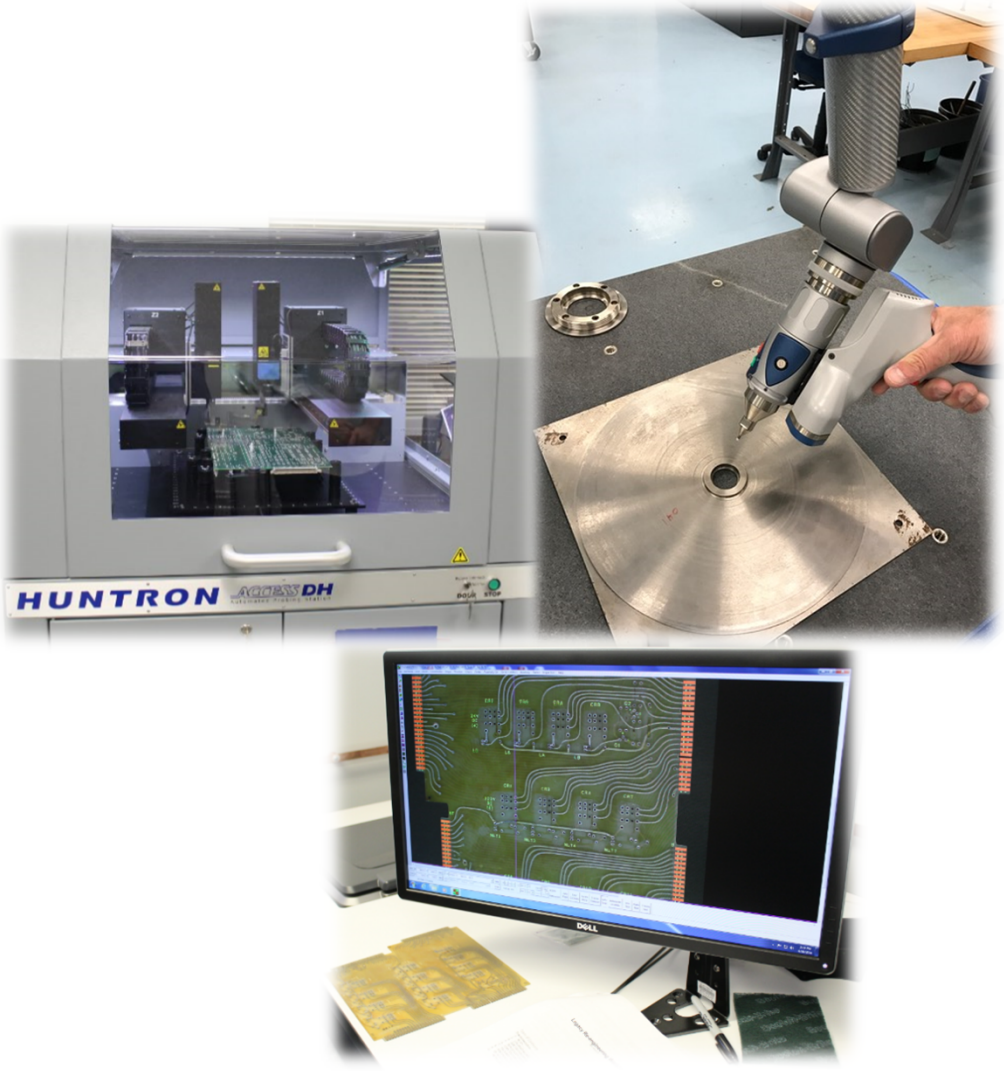


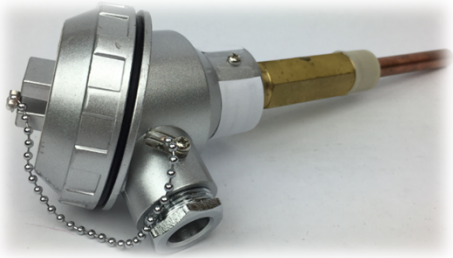
Advanced technologies

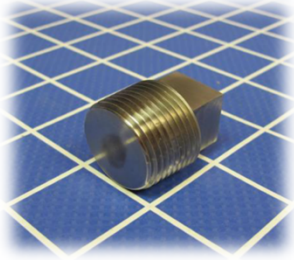
- Laser and structured light computer scanning
- X-ray computed tomography (CT) scanning
- X-Ray Fluorescence Spectrometer
- Electronic contact computer scanning
- Additive manufacturing (three-dimensional/3D printing)
- Printed Circuit Board scanning

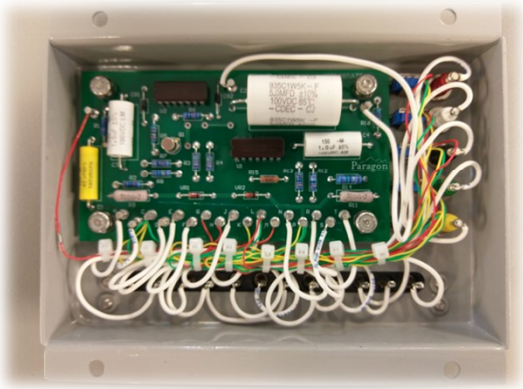


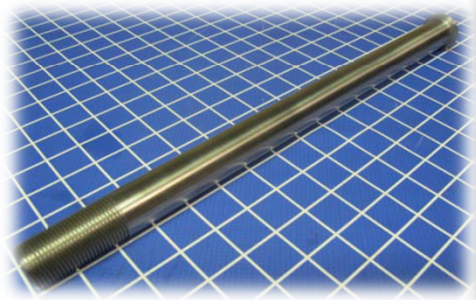
“Table-top” examples

- Describe how each process step was addressed









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