Reverse Engineering . . .

How much is enough?

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NUPIC Vendor Meeting
June 2019

What is reverse engineering?

It depends . . .

Dictionary: "The reproduction of another manufacturer's product following detailed examination of its construction or composition"

Wikipedia: "The process by which a man-made object is deconstructed to reveal its designs, architecture, or to extract knowledge from the object"

What is reverse engineering?

U.S. Army: "Reverse engineering is the process of duplicating an item, functionally and dimensionally, by physically examining and measuring existing parts to develop the technical data (physical and material characteristics) required for competitive procurement."

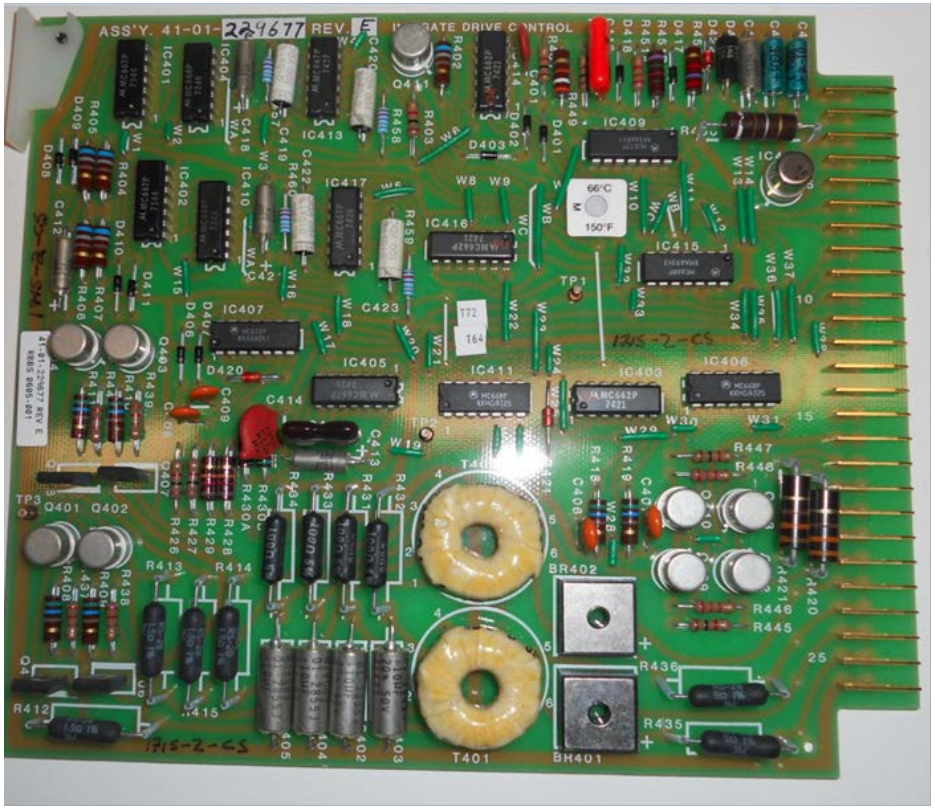
EPRI - 1998: "The process of developing technical information sufficient to duplicate an item by physically examining, measuring, or testing existing items; reviewing technical data; or performing engineering analysis."

What does "duplicate" mean?

(Verb) 1. To make an exact copy of something, 2. Identically copied from an original; 3. To do or perform again

Are these circuit cards “identical duplicates”?

ORIGINAL



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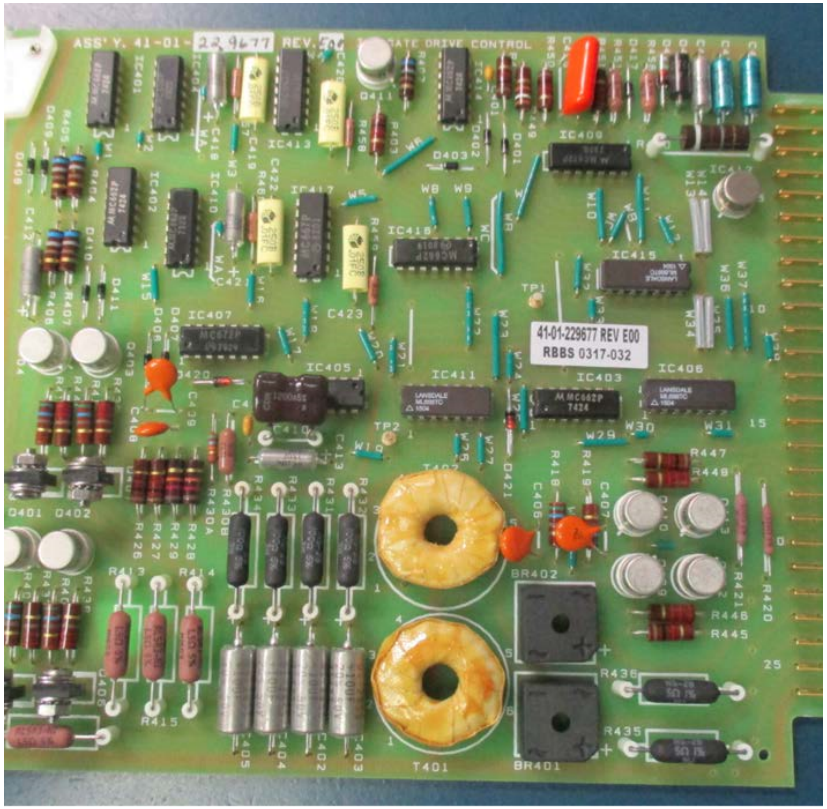
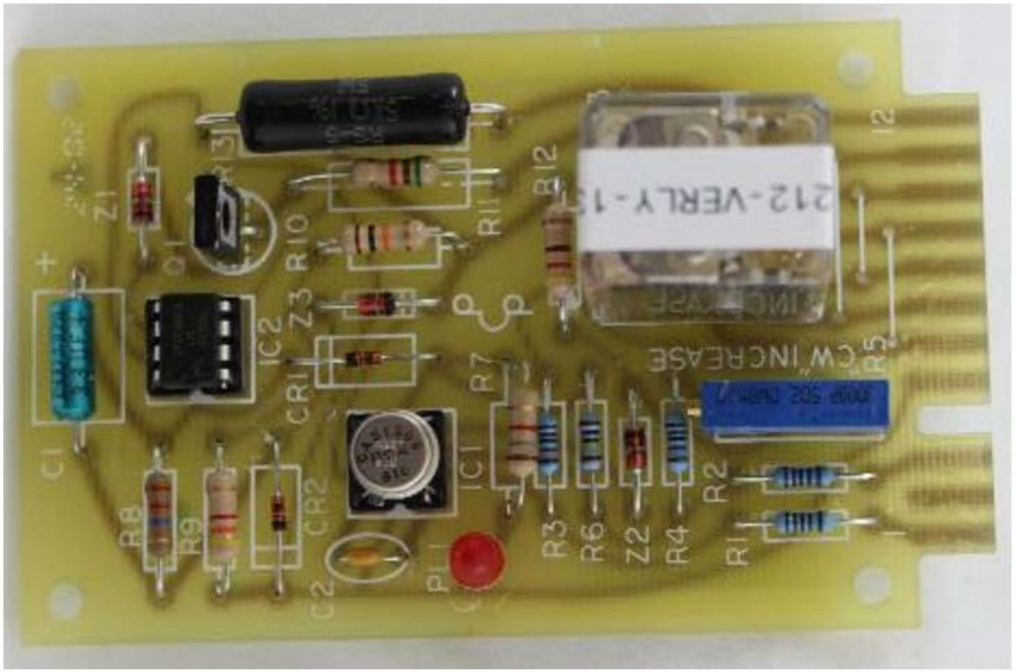


Photos courtesy of United Controls International

Are these circuit cards “identical duplicates”?

ORIGINAL



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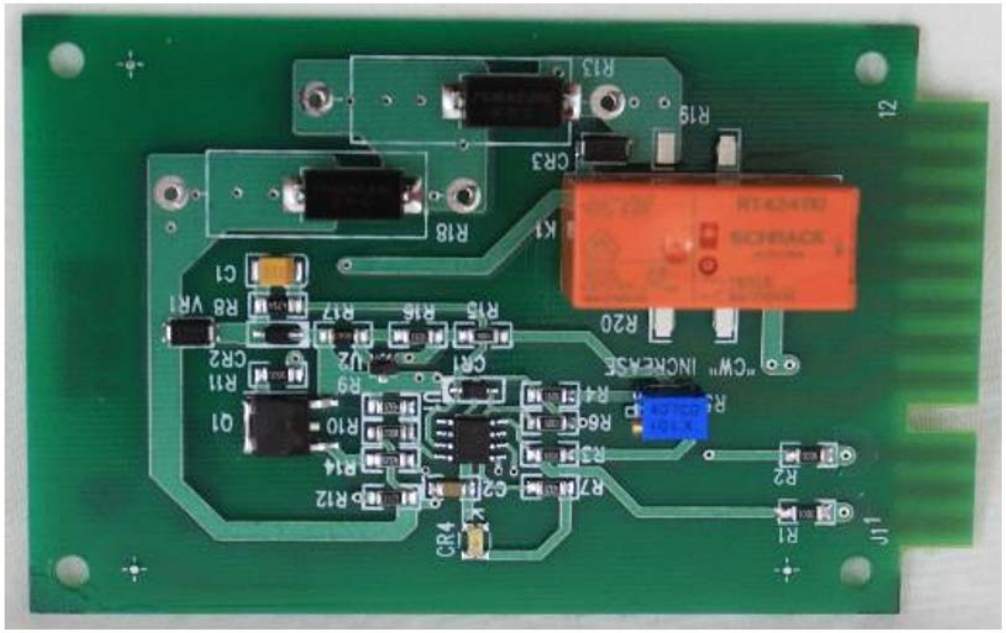
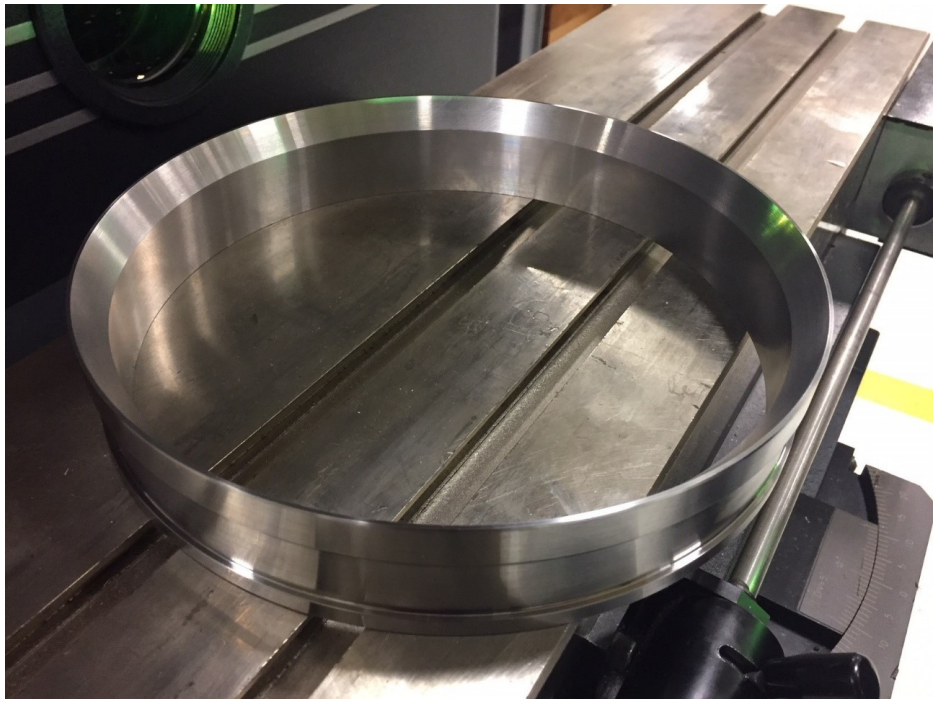


Photos courtesy of AZZ Nuclear

Are valve pressure seals “identical duplicates”?

ORIGINAL

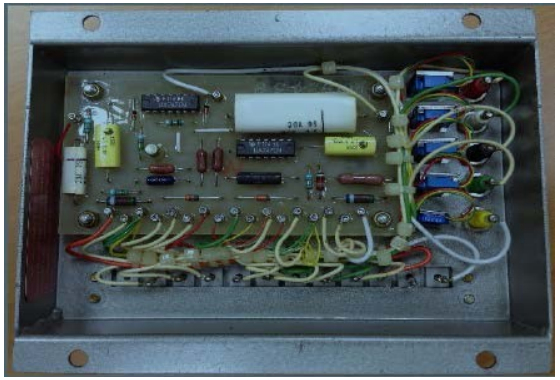
REPLACEMENT



Photos courtesy of Curtiss-Wright Nuclear Division - Nova

Are these Ramp Generator/Signal Converters identical duplicates?

ORIGINAL

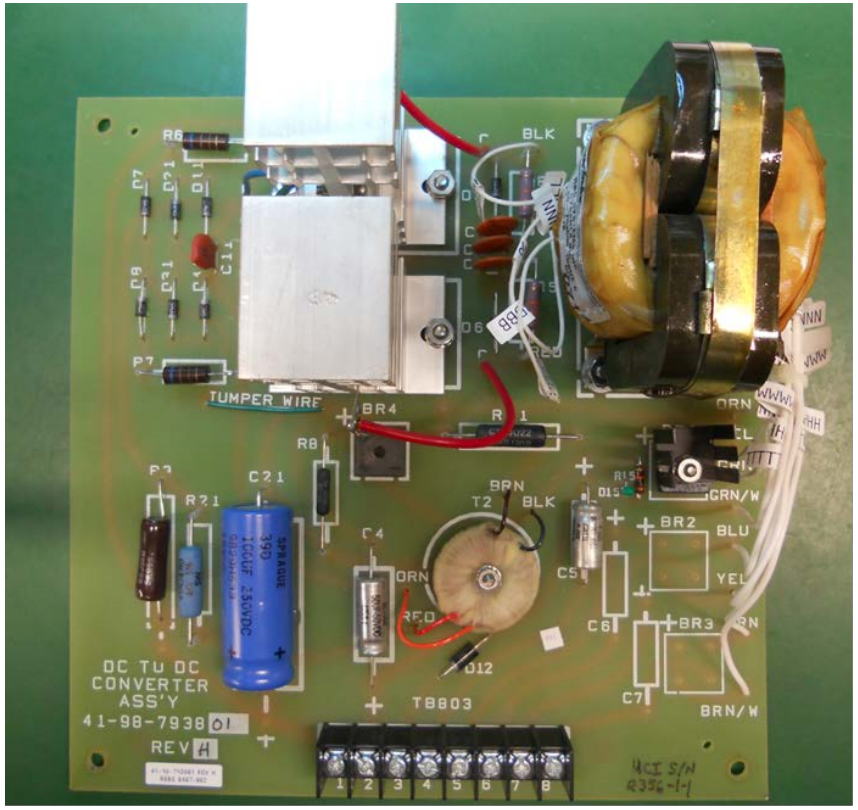


REPLACEMENT

Photos courtesy of Paragon Energy Solutions

Are these circuit cards “identical duplicates”?

ORIGINAL



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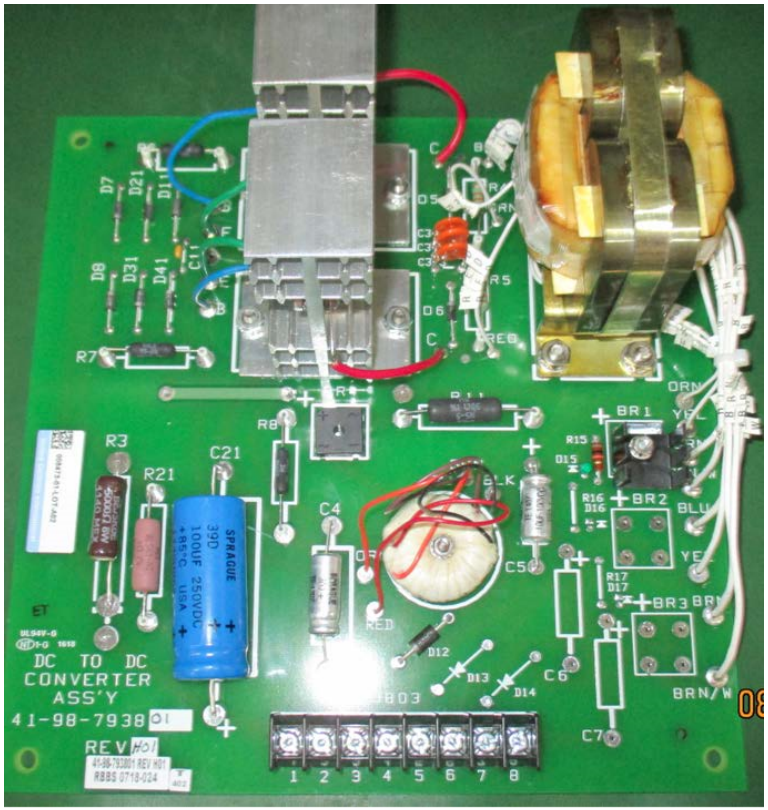
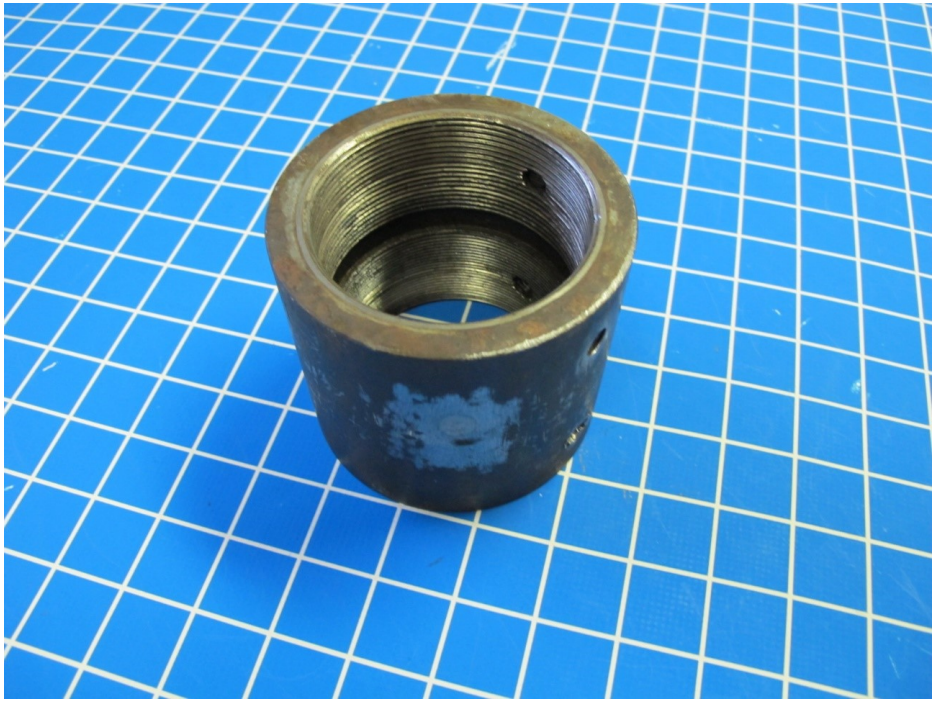


Photos courtesy of United Controls International

Are these coupling nuts “identical duplicates”?

ORIGINAL



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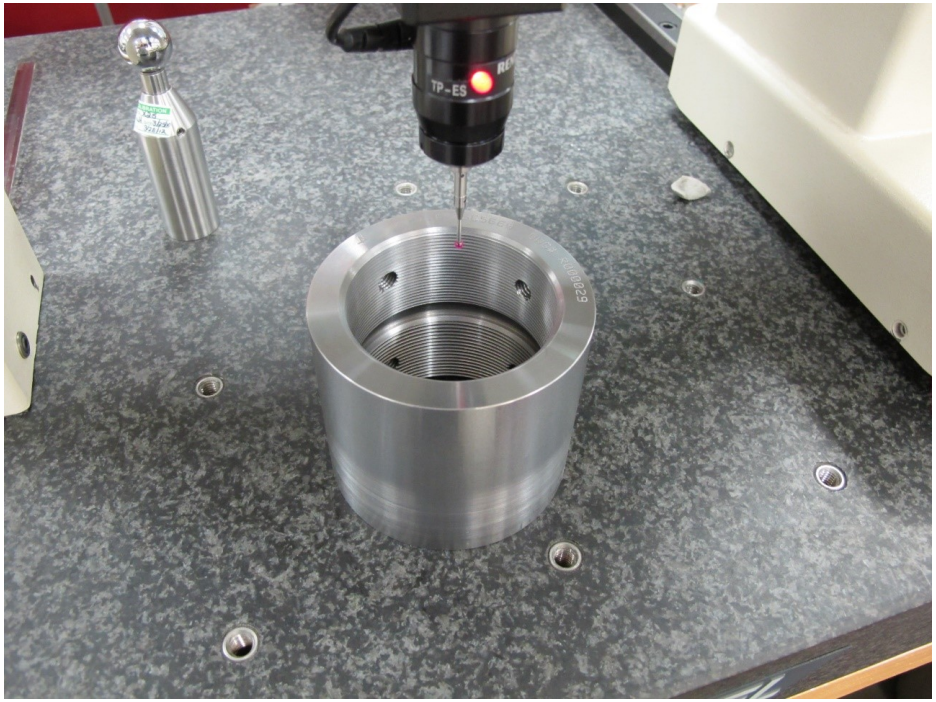


Photos courtesy of Curtiss-Wright Nuclear Division - Nova

Are these power supplies “identical duplicates”?

ORIGINAL

REPLACEMENT

Photos courtesy of AZZ Nuclear

Are these strainers “identical duplicates”?

ORIGINAL

REPLACEMENT

Photos courtesy of Curtiss-Wright Nuclear Division - Nova

EPRI research indicated . . .

- Debate about what "duplicate" means
- Confusion/debate about the word and NRC's interpretation of "identical"
  - The item has the same date code, same batch or lot number, purchased or shipped at the same time, or:
  - Item is purchased from the same vendor, provided all design, materials, or manufacturing processes are kept the same
- Regulatory perspective expressed to the RE guidance team that

  "Duplicating" or manufacturing an "identical" item involves revisiting all design considerations involved in manufacturing the original product"
- Nuclear licensees and suppliers use reverse engineering techniques for reasons other than "duplication"

Practical definition for reverse engineering?

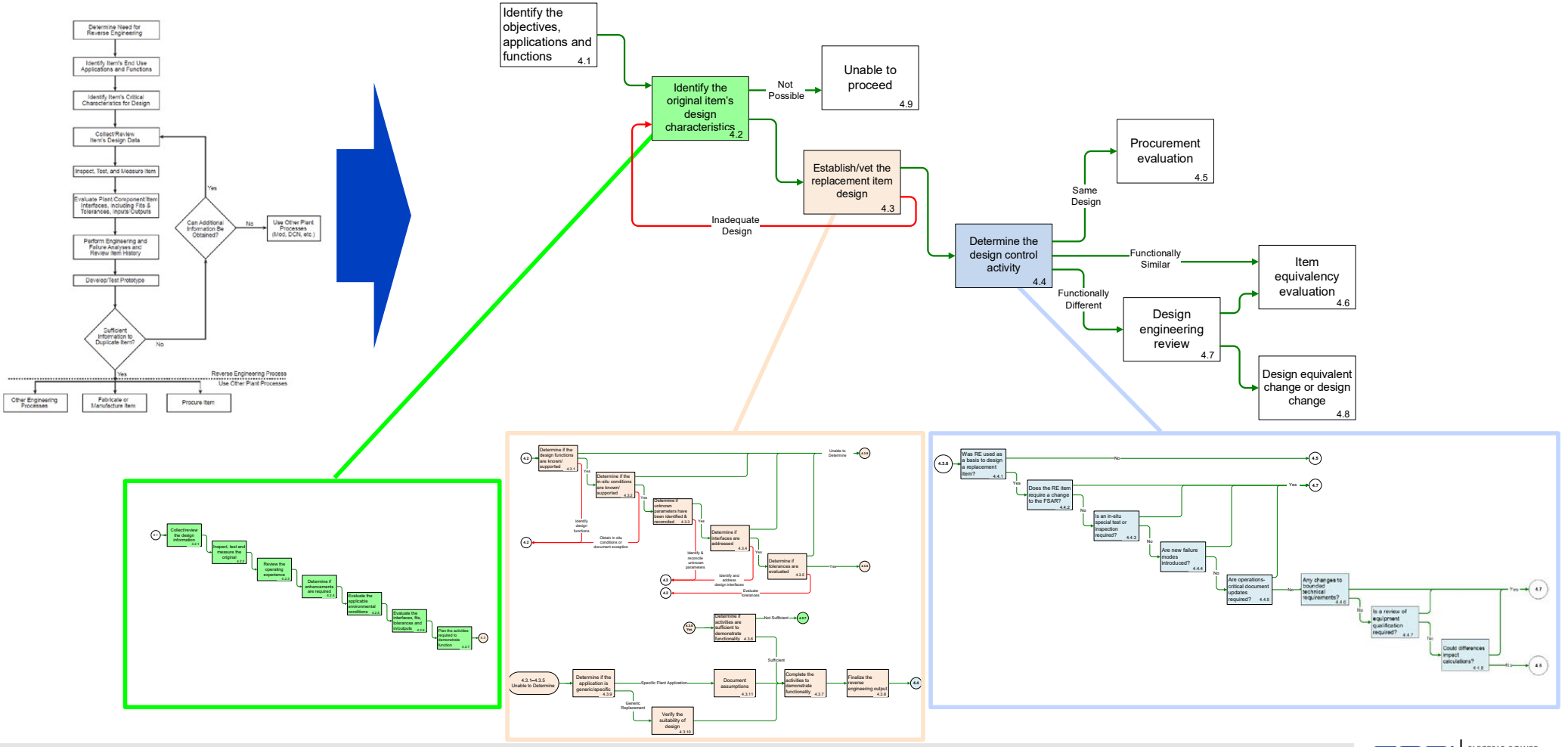
EPRI - 1998: "The process of developing technical information sufficient to duplicate an item by physically examining, measuring, or testing existing items; reviewing technical data; or performing engineering analysis."

EPRI - 2018: "The process of developing technical information sufficient to obtain a replacement for an item by physically examining, measuring, testing existing items, reviewing technical data, or performing engineering analysis."

The updated guidance on reverse engineering

- Removes “duplicate” from the definition
- Focuses on “reverse engineering techniques” and their primary applications for supporting a nuclear plant
  - Developing acceptance criteria for commercial grade dedication
  - Recovering design information required to better specify and item, perhaps enabling purchase from an alternate source
  - Recovering information sufficient to manufacture a functionally equivalent item
- Addresses licensee/supplier interface
- And . . .

It also provides an enhanced process . . .



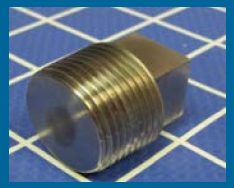
What are reverse-engineering techniques?

- 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

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

- The objective of applying reverse engineering technique is to enable manufacturing or otherwise acquiring a replacement item that will be capable of performing the original intended design functions (this includes establishing acceptance criteria).

What does “otherwise acquiring” mean?

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)	

What is most important about reverse-engineered items?

Ability to perform the same design function(s) at the items they are replacing

Could the reverse-engineered items at which we just looked be functionally equivalent to the original items?

YES – in fact, all of them are

What kind of objective evidence is needed to answer "YES"?

How much reverse engineering is enough?

It depends . . .

100	100	200	200
100	100	200	300
200	200	100	400

How do you know when enough is enough?

MULTIPLE CHOICE		ANSWER & EXPLAIN	
100	200	200	300
200	100	200	200
200	200	300	300

B

A/E 1 - Complexity of the item - 200 Points

Which is more difficult to reverse-engineer, a valve stem or a valve?

Provide at least two reasons to support your answer?

Answer

A/E 1 - Complexity of the item - 200 Points

A valve

- Multiple parts
- Parts have to work together
- Each must be examined and assigned tolerances
- Some parts may have difficult geometry to measure/reproduce
- Clearances need to be correct

3002011678, Sections Table 2-2, 2.4, 4.3

Game Board

A/E 2 – Operating Experience – 300 Points

Identify two sources of operating experience (OE) and two reasons why review of OE is important

Answer

A/E 2 – Operating Experience – 300 Points

Sources

- Maintenance history
- Corrective action
- NRC ADAMS/Part 21 reports
- Search the web
- Interview personnel

Reasons

- Identification of an adverse condition
- Identification of a gap that needs to be corrected by enhancing the design
- Identification of the need for additional discipline/licensee specific reviews and/or engineering controls (for example, preventive maintenance activities, etc.)
- Opportunities to increase design margin

3002011678, Section 4.2.3

Game Board

A/E 3 – Tolerances – 200 points

Name at least 3 techniques that can be used to develop tolerances in the absence of original design information

Answer

A/E 3 – Tolerances – 200 points

- Examine multiple specimens
- Measure surface finish to identify the machining process used, which correlates to desired accuracies
- Measure interfacing parts/items
- Examine assembled/installed item to understand clearance types (interference, clearance, etc.)
- Build and test prototypes to verify tolerances as acceptable
- Field-verify each for correct fit item after installation
- Include considerations for wear

3002011678, Sections 4.2.6,

Game Board

A/E 4 – Functionality – 200 points

Name 3 methods that can be used to demonstrate functionality of a reverse-engineered item

Answer

A/E 4 – Functionality – 200 points

- Inspection
- Testing – Function
- Testing - Interfaces
- Engineering Analysis
- Demonstrating the functionality of a replacement item designed and manufactured based on application of reverse-engineering techniques should include consideration of application requirements, plant licensing basis, interfaces, and operating environment.

3002011678, Sections 4.2.7, 4.3.6

Game Board

A/E 5 – In-Situ Conditions – 300 points

Can in-situ conditions (in addition to nameplate data) be important when verifying function? What should be done if this information is not available?

Answer

A/E 5 – In-Situ Conditions – 300 points

- **Yes** - it may be necessary to obtain information related to actual in situ conditions (for example, overvoltage and undervoltage) when planning tests to verify function.

- In the absence of in-situ information (for example, the reverse-engineered design and associated testing are based nameplate data), the assumptions should be included, as appropriate, in documentation such as RE output and certification

NRC IN 2016-09
3002011678, Sections 4.2.7, 4.3.2

Game Board

A/E 6 – Design Assumptions – 300 points

What can be done to address assumptions include in the design of a reverse-engineered item?

Answer

A/E 6 – Design Assumptions – 300 points

- Assumptions should be clearly documented in the reverse engineering output documents

- Assumptions should be accounted for when establishing suitability of design

NRC IN 2016-09
3002011678, Sections 4.2.7, 4.3.2

Game Board

MC 1 - Environmental Conditions - 100 points

True or False?

Qualification (suitability of design) must be established for a reverse-engineered item that is subject to equipment qualification requirements (i.e. environmental, seismic, electromagnetic, or radio-frequency, etc.)?

Answer

MC 1 - Environmental Conditions - 100 points

True

Qualification must be established, this is typically accomplished by qualification testing

3002011678, Sections 4.2.5, 4.2.7, 4.3.6, 4.3.7, 4.3.8, 4.8, Table 4-2,

Game Board

MC 2 – Multiple Applications – 200 points

True or False?

A supplier must document product capabilities (specification) and verify suitability of design for the documented capabilities before marketing a reverse-engineered item as a “generic” aftermarket replacement?

Answer

MC 2 – Multiple Applications – 200 points

True

Qualification must be established, this is typically accomplished by qualification testing

10CFR50, Appendix B, Criterion III
NRC IN 2016-09
3002011678, Table 2-1

Game Board

MC 3 – Design Functions – 200 points

True or False?

An item can be reverse-engineered for use in a safety-related application without knowledge of it's design functions

Answer

MC 3 – Design Functions – 200 points

False

The objective of reverse engineering is to enable manufacturing or otherwise acquiring a replacement item that will be capable of performing the original intended design functions.

10CFR50, Appendix B, Criterion III
NRC IN 2016-09
3002011678, 1.2, 1.6, 4, 5, 6

Game Board

MC 4 – Interfaces – 100 points

True or False?

Determining if interfaces are adequately addressed for electrical items typically involves evaluating inputs and outputs, physical configuration, and mounting, as well as ensuring that the equipment is configured correctly (for example, dip switches, jumpers, and so forth)

.

Answer

MC 4 – Interfaces – 100 points

True

For mechanical items, this would typically involve evaluating linkages, physical connections, clearances and fits, wear surfaces, mating surfaces, material, compatibility, and mounting.

3002011678, 4.3.4

Game Board

MC 5 – Specimens – 200 points

True or False?

Previously installed (used) and even inoperable specimens can be used as the basis for reverse engineering an item

Answer

MC 5 – Specimens – 200 points

True

However, considerations should be made for wear, and additional activities may be needed to verify function, interfaces, etc.

3002011678, 3.1.1, 3.2.2, 4.2.2

Game Board

MC 6 – Unknowns – 200 points

True or False?

When less information is known about the original design, the amount of activities necessary to establish ability to perform design function(s) increases

Answer

MC 6 – Unknowns – 200 points

True

3002011678, 4.3.3

Game Board

Bonus Round

200

200

200

200

E

BR1 – NRC Document – 200 points

What is the most recent generic NRC communication on reverse engineering?

Answer

BR1 – NRC Document – 200 points

NRC Information Notice 2016-09

Game Board

BR2 – Counterfeiting – 200 points

When might reverse-engineering be considered as counterfeiting?

Answer

BR2 – Counterfeiting – 200 points

When there is intent to deceive – for example, a reverse-engineered item is represented as an authentic original OEM item without the legal right to do so

Game Board

BR3 – Original design information? – 200 points

Name 3 types of entities that have original design information?

Answer

BR3 – Original design information? – 200 points

- Original equipment manufacturers
- Original equipment manufacturer's sub-tier suppliers
- Original equipment suppliers / nuclear steam system suppliers
- Architect/Engineering firms
- Licensees

Game Board

BR4 –Reverse Engineering Output – 200 points

Name 3 types of reverse engineering output documents?

Answer

BR4 –Reverse Engineering Output – 200 points

- Enhanced description
- Fabrication drawings
- Manufacturing information
- Bills of material
- Schematics
- Wiring diagams
- Qualification test records and results
- Component-level specifications

Game Board

Summer 2019 JUTG

- August 13-15, SandPearl, Clearwater, FL

Winter 2020 JUTG

- January 28-30, Hilton Bayfront St. Petersburg, FL
- Joint meeting with NUPIC

Summer 2020 JUTG

- August 4-6, 2020, SandPearl, Clearwater, FL

Procurement-Related Instructor-Based Training Open Sessions at EPRI in Charlotte, NC

Course	Dates
Nuclear Utility Procurement	July 15-17, 2019
Procurement of Reactor Coolant Pressure Boundary Replacement Items (ASME procurement)	July 18-19, 2019
NUPIC Audit Team Leader Training	August 13-15, 2019
Nuclear Utility Procurement	December 3-5, 2019

Courses are also available for on-site delivery
Please contact Lori at lwarneke@epri.com for more information

EPRI U is live – complete with a learning management system

- Some CBTs related to procurement are now available

Nuclear Supply Chain Training - Warehouse Inventory Management...

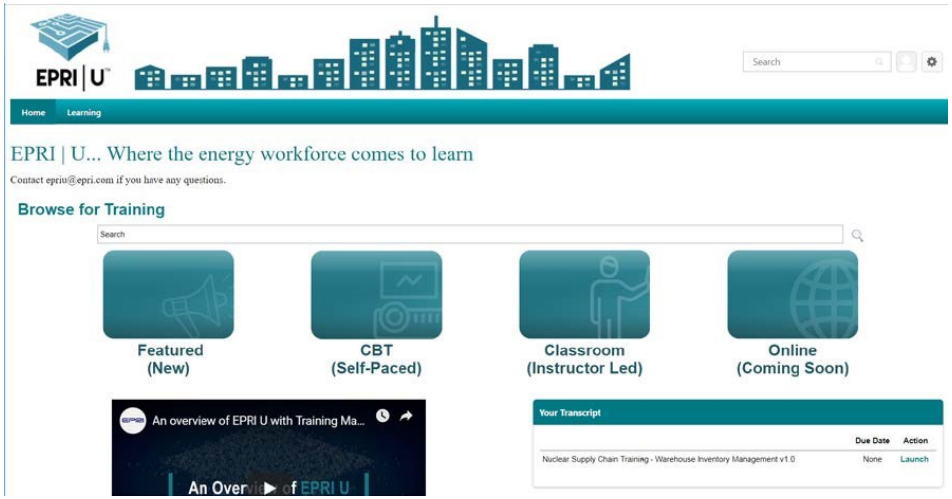
(0)

Obsolescence Program Manager Computer Based Training (CBT) v1.0

(0)

Quality Control Receipt Inspection - Computer Based Training

(0)



- Other are in the queue
  - Audit Technical Specialist (3002006989)
  - Procurement Engineering Basics (3002005397)
  - Procurement Engineering Safety Classification (3002011679)
  - Undeclared Digital Content (3002009558)
- Non-Member, training-only login IDs are available

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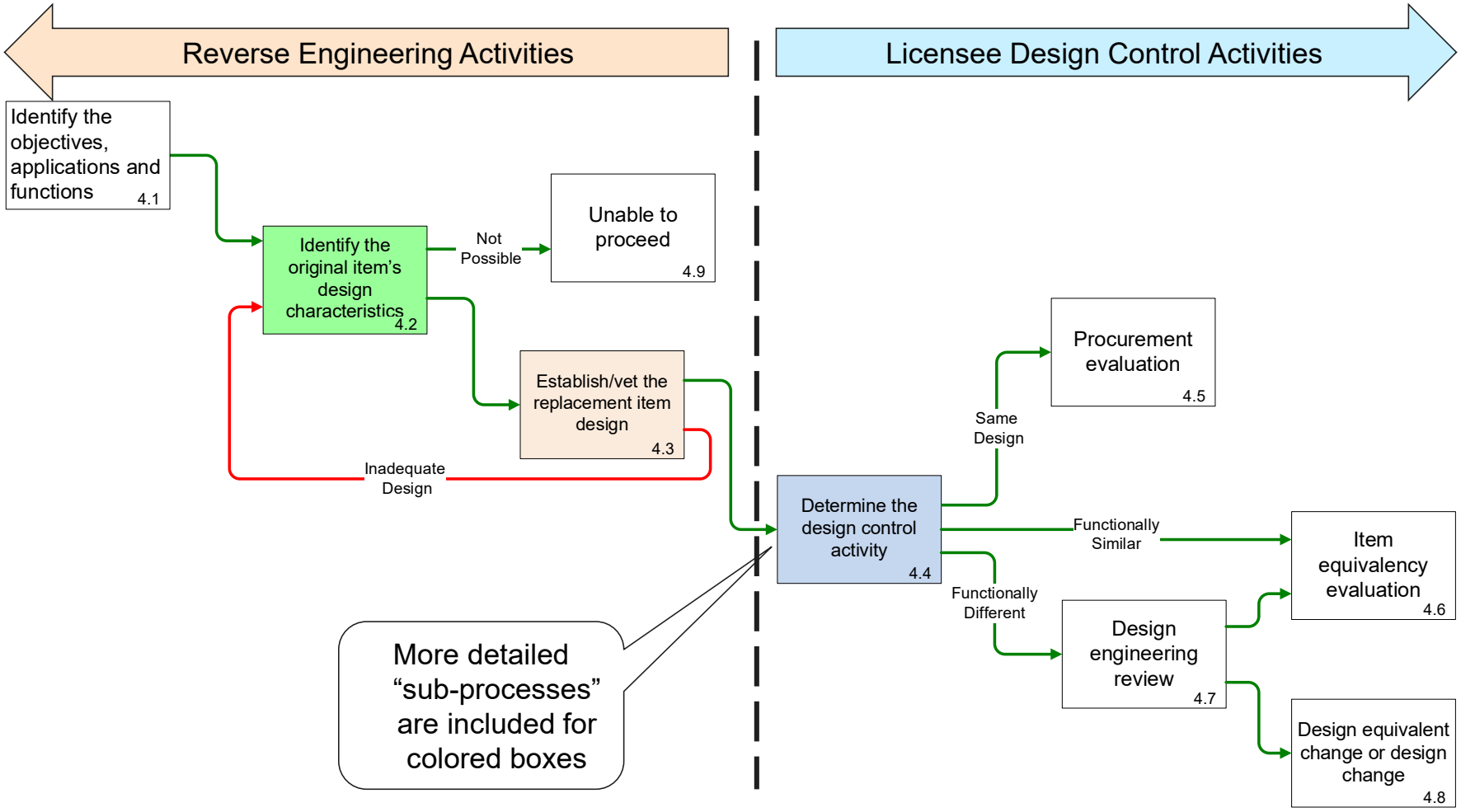
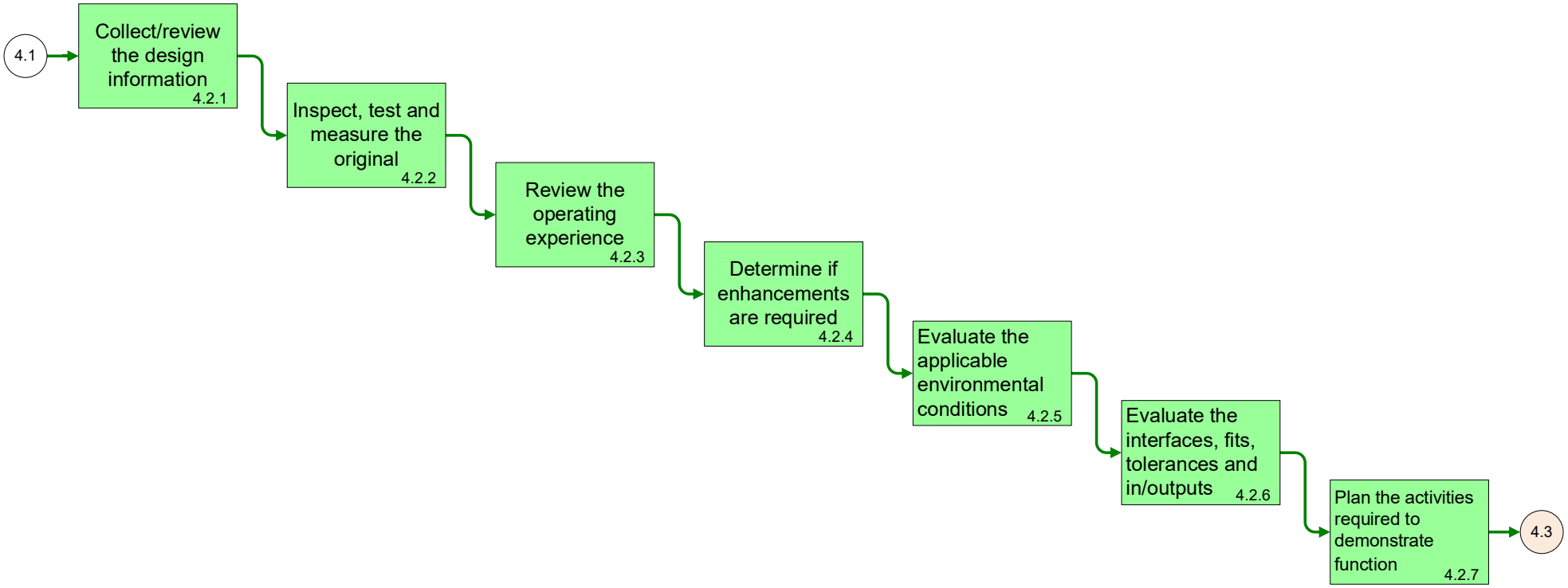
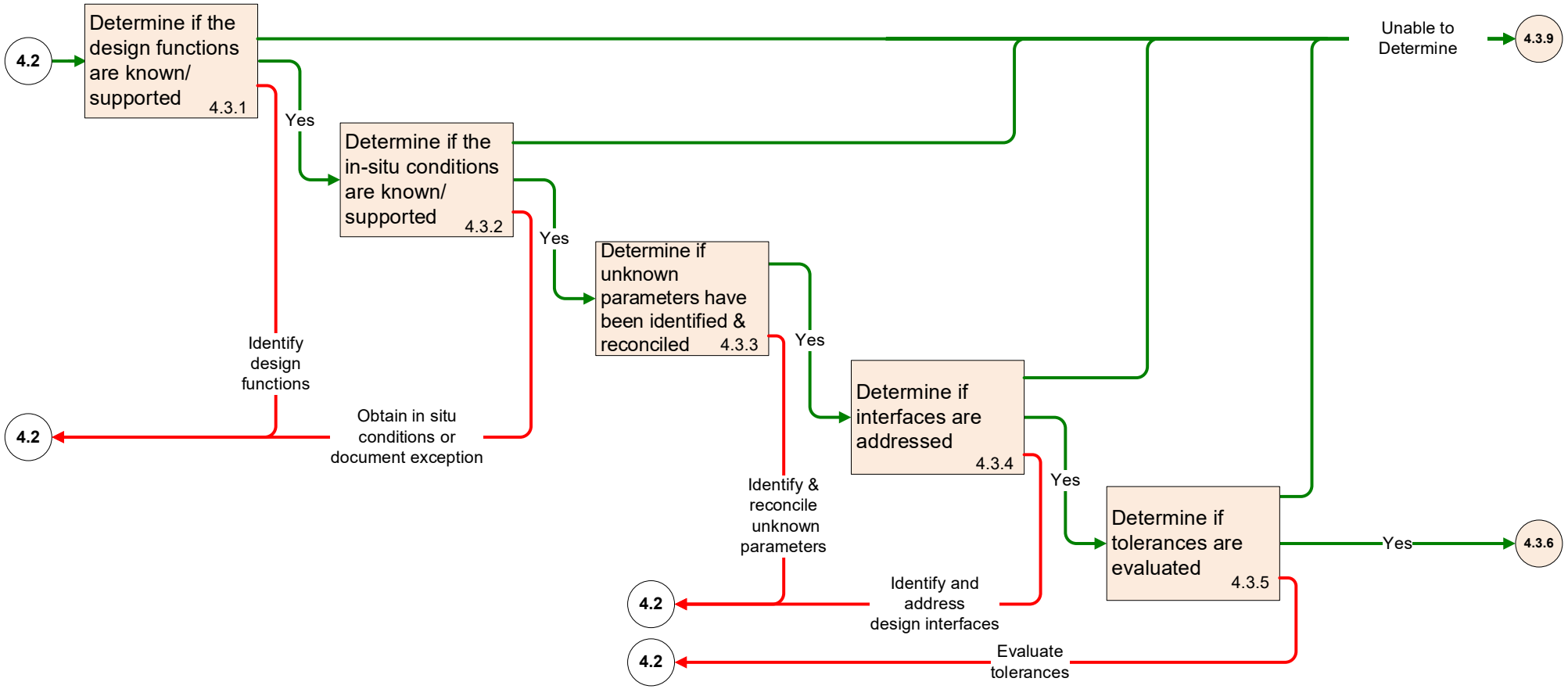
Basic process for applying reverse-engineering techniques



Identify the Original Item's Design Characteristics



Establish/vet replacement item design



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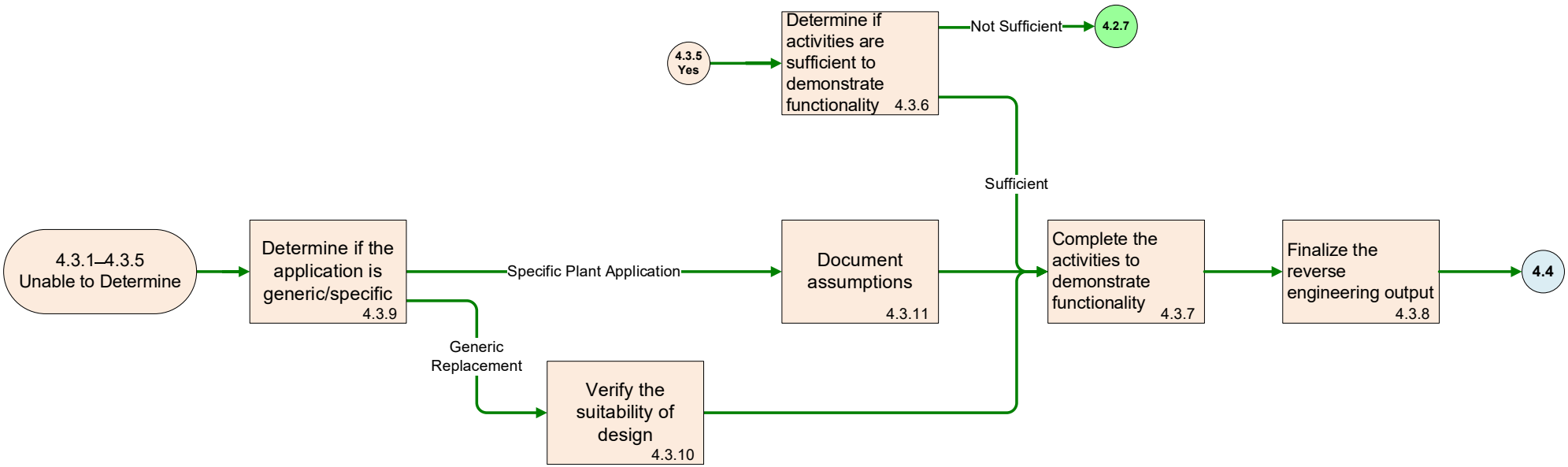
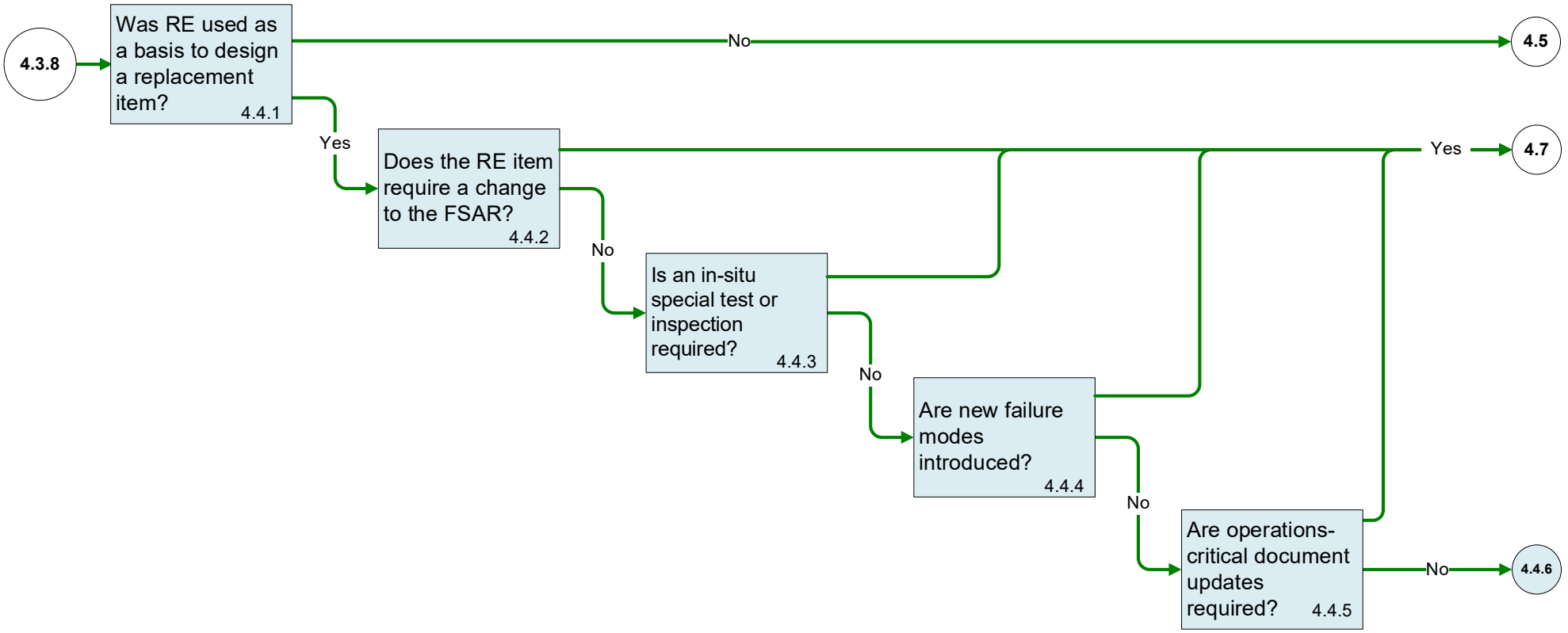


Determine design control activity



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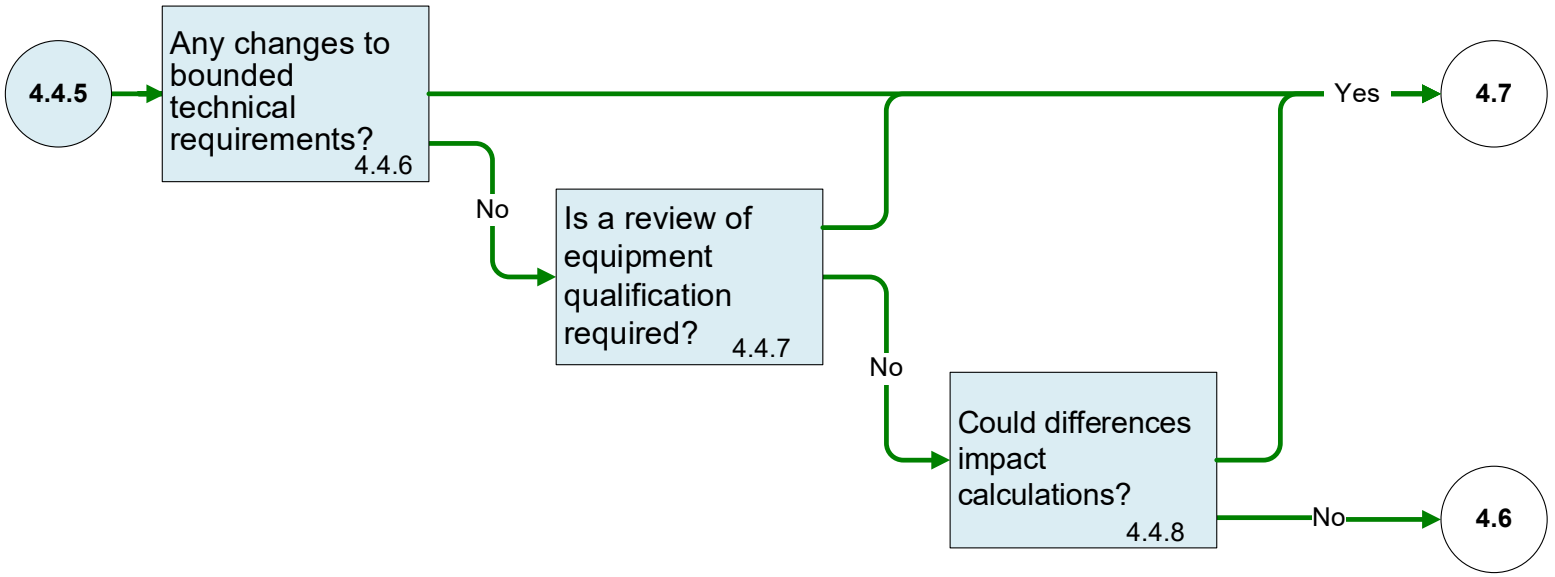

Determine the appropriate design control activity

- Procurement Evaluation (4.5) if RE was only used to develop a better purchase description
- Design Review to determine if Design Change/ Design Equivalent Change (4.8), or Equivalency Evaluation (4.6) is appropriate when the RE Design:
  - Requires change to FSAR
  - Requires in-situ engineering or special test
  - Introduces a new failure mode
  - Requires updates to operations-critical documents
  - Requires changes to bounded technical requirements
  - Requires review of equipment qualification
  - Requires updates or changes to calculations