Advanced Manufacturing Technologies Application Guidance Draft Framework

Subtask 2C of AMT Action Plan

Public Meeting
July 30, 2020

U.S.NRC
United States Nuclear Regulatory Commission
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Purpose of this Presentation

- Discuss NRC Application Guidance Draft Framework for components using Advanced Manufacturing Technologies (AMTs) with NRC stakeholders.
- Receive comments and suggestions from NRC stakeholders to inform development of NRC Application Guidance.
  - Provide recommendations for licensee submittals and associated staff review to promote efficient review and approval of AMTs for safety related components.

AMT Application Guidance Framework

- The draft framework provides a starting point for discussion on potential guidance regarding the use of AMTs.
- AMTs include techniques and material processing methods not traditionally used in the US nuclear industry that have yet to be formally standardized by the nuclear industry and approved by the NRC (e.g., ASME Code, topical report).
- AMTs can include new ways to fabricate or join components, surface treatments, or other processing techniques to provide a performance or operational benefit.

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General Review Philosophy

- Framework and associated guidance must be sufficient and flexible.
- Currently there are two conventional paths to demonstrating that an AMT component is acceptable and will fulfill its intended function.
  - Equivalency Approach: attributes of the AMT component meet or exceed the original design and performance requirements. (e.g., equal to or greater than tensile, yield, fracture toughness, SCC resistance).
  - Design Modification: Provide technical justification for changing existing requirements. For example, the original material provided significant margin compared to what is necessary for the component to meets its intended function.

Regulatory Pathways

- 10 CFR 50.59 Changes, tests and experiments
  - Subtask 2A of AMT Action Plan, Rev. 1
  - Document will be out for public comment soon
- License amendment (Technical Specification change etc.)
- 10 CFR 50.55a Codes and Standards
  - (z) Alternatives to codes and standards
    - (1) Acceptable level of quality and safety
    - (2) Hardship without a compensating increase in quality and safety
- Rulemaking

10 CFR 50.55a(z)(1)

- An applicant must demonstrate that the AMT component provides an acceptable level of quality and safety.
  - Meets the same design requirements as an ASME component.
  - Example: An AMT component material is not produced using an approved ASME Code material specification and is not equivalent to the original code material.
    - Meets ASME Code Section III design allowables
    - Fulfills the material requirements in the design (e.g., tensile, yield, fracture toughness)
    - Fulfills the intended function of the component

10 CFR 50.55a(z)(2)

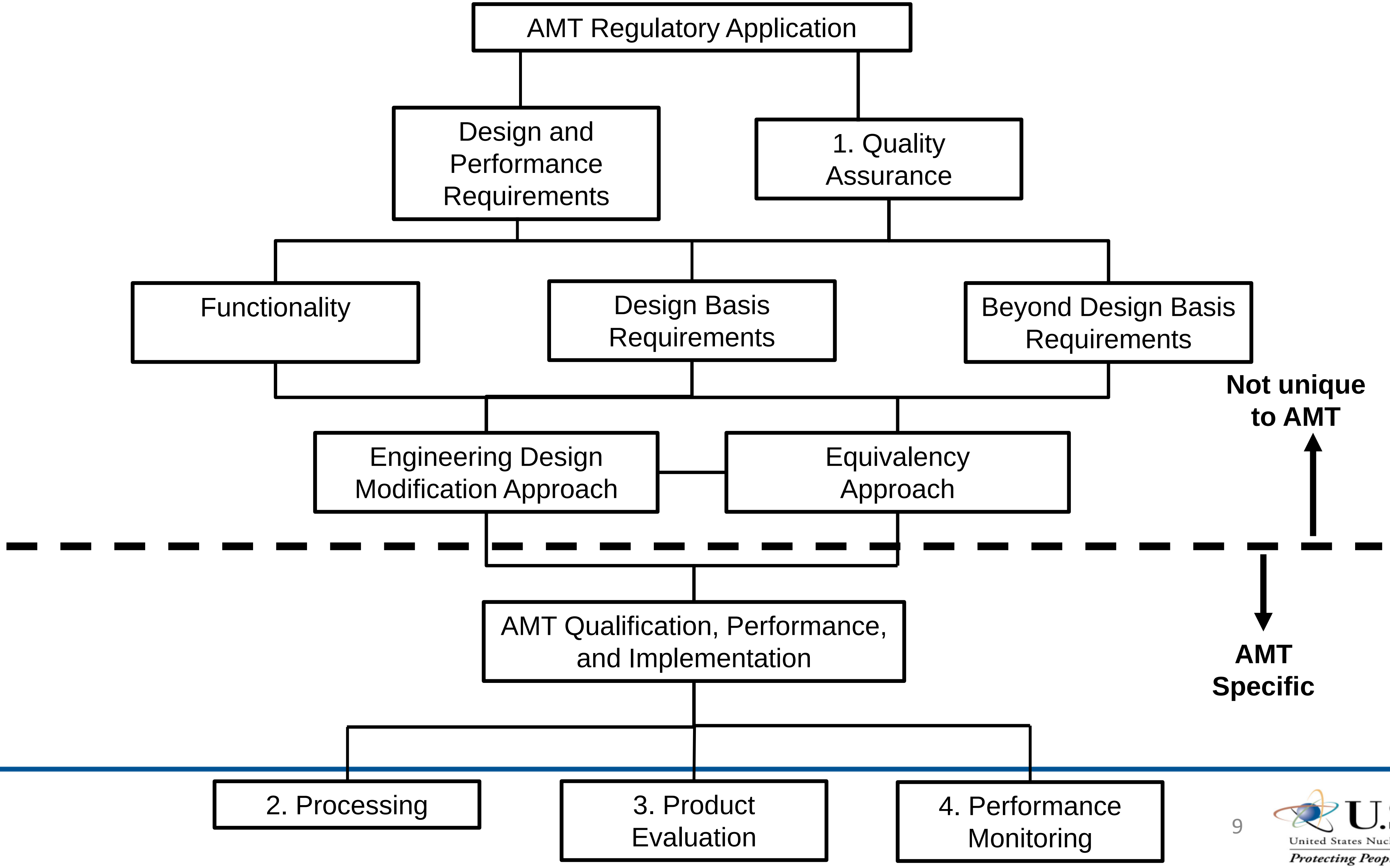
- An applicant must demonstrate that compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.
- Example: ASME Code Class 2 or 3 pump can no longer remain in service due to a degraded pump case housing component.
    - The OEM is no longer in business
    - A suitable Code compliant component will take several months or longer to procure
    - The AMT component material is not equivalent to the original material
    - The AMT component does not meet the original design requirements
    - The AMT component will fulfill the intended function of the component
- The AMT component may be acceptable if the licensee demonstrates that the AMT component/part fulfills its intended safety function. Risk insights may also be considered.

Process Flow Chart

The process flow chart in Appendix A to the AMT Application Guidance Framework document, along with definitions and short descriptions, describes a holistic approach to the qualification and performance considerations for any system, structure, or safety significant component (SSC), including the underlying material and fabrication process.

- The flow chart is intended to cover a broad range of AMTs and be a guide which outlines the types of information that could be included in a licensee's request to facilitate the NRC's review.
- Depending on the AMT process used, some of the information in the flow chart may not be necessary.
- The focus of the information should be on those unique attributes associated with AMT qualification and performance compared to conventionally manufactured SSCs.
- The application may leverage relevant aspects of ASME and ASTM standards that prescribe certain testing requirements for conventionally manufactured items.

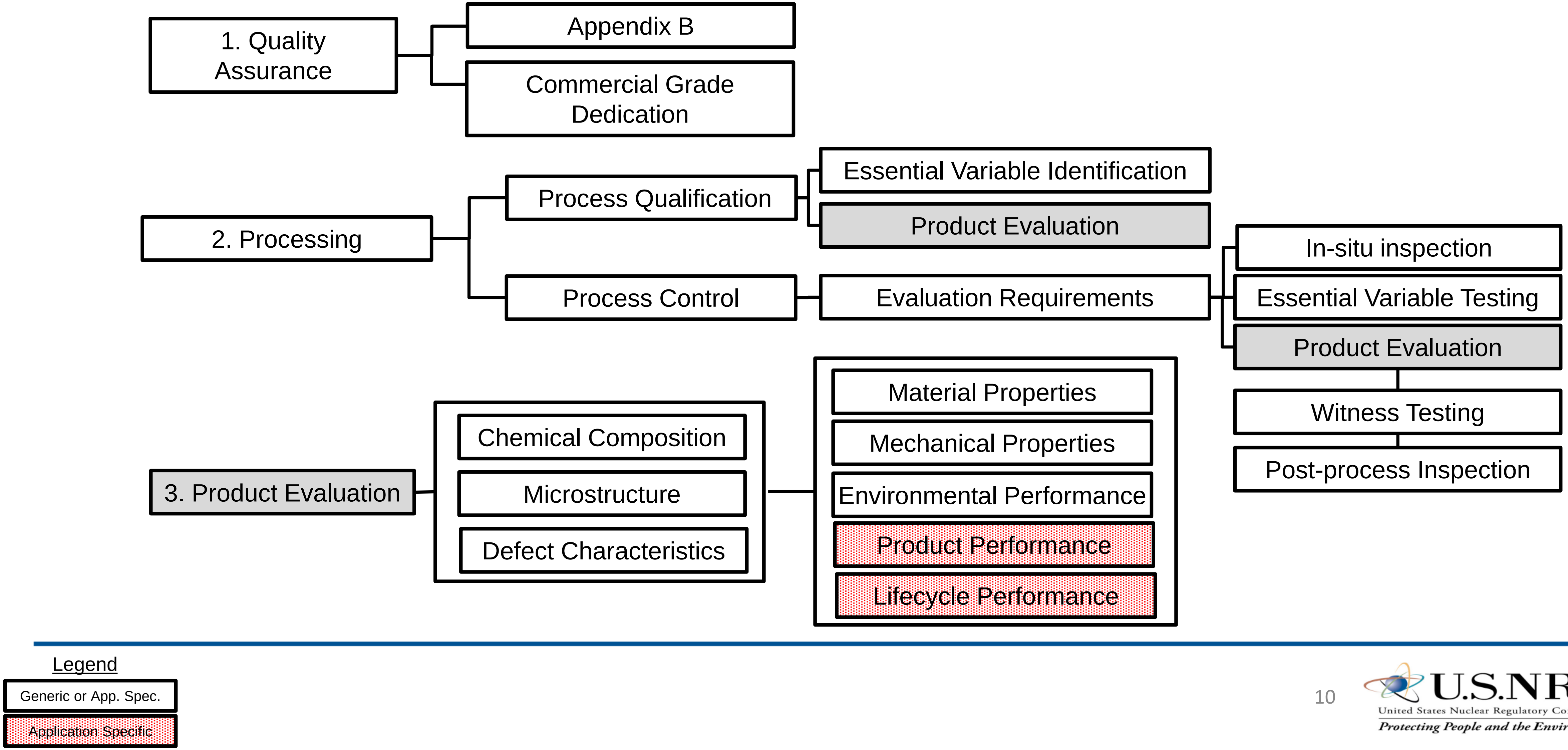
AMT Application Guidance



AMT Application Guidance

Address differences between a particular AMT and conventional materials/processes;

Not all aspects of this flow chart are needed for a particular AMT application



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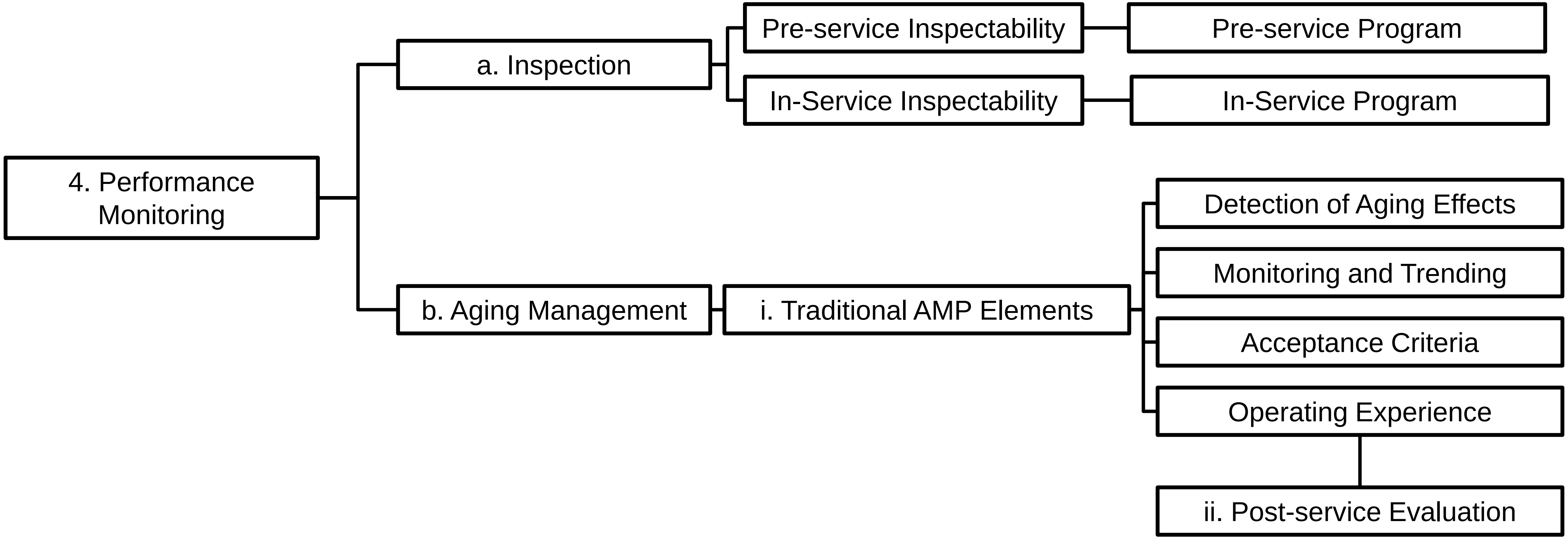

Quality Assurance

- Process followed during the manufacture and implementation of AMTs to proactively ensure adherence to quality assurance (QA) requirements (e.g., 10 CFR Part 50, Appendix B) and/or established methods.
  - QA programs will need to be established for those aspects of AMT manufacturing or implementation that are novel or unique.
- Two options
  - The product is governed by a QA program that meets 10 CFR Part 50, Appendix B requirements.
  - Commercial Grade Dedication (CGD) – assurance can be achieved by completing a CGD process described in EPRI 3002002982, Revision 1 to EPRI NP-5652 and TR-102260, “Plant Engineering: Guideline for the Acceptance of Commercial-Grade Items In Nuclear Safety-Related Applications,” endorsed in Regulatory Guide 1.164.

Process Qualification

- The steps taken to develop, and then demonstrate, that the product will be produced with characteristics that will meet the intended design requirements.
  - Essential Variable Identification – Determining the process and post-processing parameters that need to be controlled to ensure acceptable product performance.
  - Product Evaluation – an evaluation, over the allowable essential variable range(s), of the corresponding product properties that are required for meeting the design requirements.
    - Examples include chemical composition, microstructure, defect characteristics, weldability, and both basic mechanical properties (e.g., tensile, hardness, Charpy) that are important for any application but also properties that may only be important to a specific application (e.g., fatigue life, SCC resistance).

Process Control

- The steps taken to verify that each product will be produced in accordance with the qualified process and reestablish the qualified process if needed.
- Evaluation Requirements– The approach, techniques, and frequency used to evaluate the qualified process.
  - Should evaluate all essential variables individually or in appropriate combinations to ensure they fall within qualified ranges.
  - May include in-situ inspection during the production process, direct monitoring or testing of essential variables, and/or aspects of product evaluation.

Process Control

- Special categories of product evaluation include witness testing and post-process inspection.
  - Witness testing is often performed on separately-produced specimens (e.g., weld run-off tab) to measure properties demonstrated during process qualification to ensure they remain acceptable.
  - Post-process inspection could entail both non-destructive or destructive evaluation to, for example, characterize defects, chemistry, or microstructure.
- Frequency: the process can be evaluated for every manufactured product, by periodically sampling a subset of like products or processes, or when aspects of the production changes.

Product Evaluation

- Product performance either needs to be demonstrated or coupled with performance monitoring actions to provide assurance that the design requirements are met over the product's intended service life.
  - For example: The acceptability of any necessary joining techniques may also need to be considered.
- Performance Demonstration – objective is to demonstrate that the performance of the product will be acceptable.
  - A combination of material (e.g., density, modulus) and mechanical testing (e.g., strength, toughness), environmental testing and evaluation (TE), product TE, and lifecycle TE may be used.
  - Mechanical and environmental testing can establish basic property information that can then be used to show, through additional analysis, that the design requirements are met.
  - Product TE can be used to directly demonstrate that certain design requirements are satisfied (e.g. burst testing for a pressure retaining component).
  - Lifecycle TE is a subset of product TE that is intended to bound or represent the service conditions over the product's intended lifetime to demonstrate that the design requirements are met.

Performance Monitoring

- Inspection
  - Goal is to identify those manufacturing defects / non-conformances or service-induced degradation that may result in unacceptable product performance.
  - Inspectability – aspects of the microstructure, material interfaces, defect characteristics, component and system design (e.g., accessibility, geometry) that most challenge performing effective inspections for the product should be identified and assessed.
- Aging Management
  - Traditional AMP Elements – likely to be most relevant for AMTs: Detection of aging effects, monitoring and trending, acceptance criteria, and operating experience.
  - Post-service Evaluation – optional and may be considered in conjunction with in-service inspection to demonstrate safety by gaining information on material properties and performance after time in service.

Questions ?

Suggestions ?