NRC Regulatory Approach for Advanced Manufacturing Technologies

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December 10, 2020

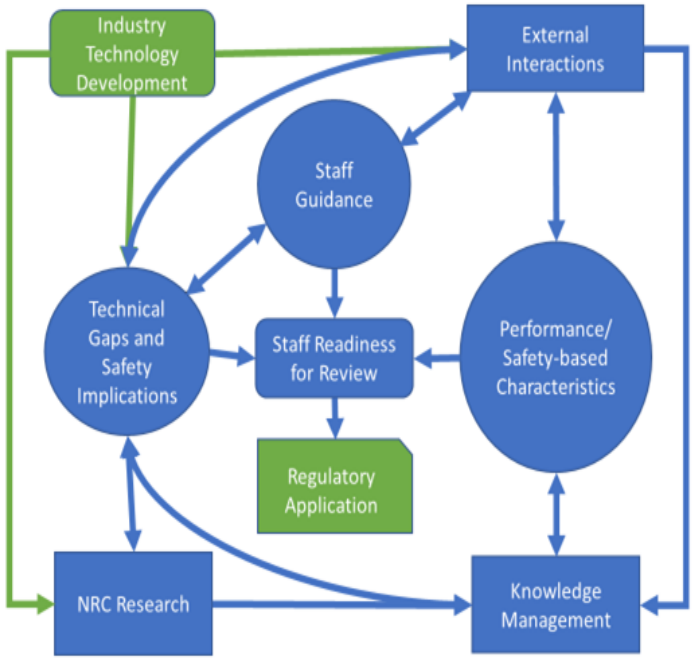
Advanced Manufacturing Technologies

- Techniques and material processing methods
  - Not traditionally used in the U.S. nuclear industry
  - Not formally standardized/codified by the nuclear industry

- Initial AMTs based on industry interest:
  - Laser Powder Bed Fusion (LPBF)
  - Direct Energy Deposition (DED)
  - Cold Spray
  - Electron Beam Welding
  - Powder Metallurgy - Hot Isostatic Pressing (PM-HIP)

Action Plan, Rev. 1 - Tasks

- Task 1 - Technical Preparedness
  - Technical information, knowledge and tools to prepare NRC staff to review AMT applications
- Task 2 - Regulatory Preparedness
  - Regulatory guidance and tools to prepare staff for efficient and effective review of AMT-fabricated components submitted to the NRC for review and approval
- Task 3 - Communications and Knowledge Management
  - Integration of information from external organizations into the NRC staff knowledge base for informed regulatory decision-making
  - External interactions and knowledge sharing, i.e. AMT Workshop



Technical Preparedness Activities (Task 1)

Subtask 1A: AMT Processes under Consideration

- Perform a technical assessment of selected AMTs (Laser Powder Bed Fusion, Directed Energy Deposition, PM HIP, EB-welding, and Cold Spray)
- Gap assessment for each selected AMTs vs traditional manufacturing techniques

Subtask 1B: Inspection and NDE

- Assess the state of technologies in the testing and examination of AMTs
- Will inform staff decisions related to use of NDE on AMT-fabricated components

Subtask 1C: Modeling and Simulation of Microstructure and Properties

- Evaluate modeling and simulation tools used to predict the initial microstructure, material properties and component integrity of AMT components
- Identify existing gaps and challenges that are unique to AMT compared to conventional manufacturing processes
  - Survey of Modeling and Simulation Techniques for Advanced Manufacturing Technologies:
    - Volume I – Predicting Initial Microstructures (ML20269A301)
    - Volume II - Predicting Material Performance from Material Microstructure

Regulatory Preparedness Activities (Task 2)

Subtask 2A: Implementation using the 10 CFR 50.59 Process

- Provide guidance and support to regional inspectors regarding AMTs implemented under 50.59

Subtask 2B: Assessment of Regulatory Guidance

- Assess whether any regulatory guidance needs to be updated or created to clarify the process for reviewing submittals with AMT components
- Complete: ML20233A693

Subtask 2C: AMT Guidelines Document

- Develop guidelines which describe the generic technical information to be addressed in AMT submissions
- Public meeting discussing initial framework was held July 30, 2020 https://www.nrc.gov/pmns/mtg?do=details&Code=20200816
- Meeting summary: ML20240A077

Implementation Using the 10 CFR 50.59 Process - Background (Subtask 2A)

- Industry identified 10 CFR 50.59 as the regulatory path for initial AMT components at U.S. NPPs.
- Staff performed a preliminary review of the 50.59 process for changes to use AMT components.
- In-depth development based on consensus inputs from many NRC counterparts.

  Multiple rounds of review & comment from regulatory and technical subject matter experts in the Regions, NRR, and RES; and from OGC attorneys.

- Staff's review expanded to address technical QA criteria for design control & procurement in addition to 50.59.

Implementation Using the 10 CFR 50.59 Process - Purpose & Status (Subtask 2A)

Purpose of the Draft Paper

- Document staff review of how a change to use an AMT component could be implemented at a plant under QA controls and the 10 CFR 50.59 process.
- Changes in the facility made without prior application for NRC review & approval.
- Focus is 10 CFR Part 50, Appendix B and 10 CFR 50.59 requirements and guidance.

Status

- The NRC requests comments from the public on the draft document for AMT Subtask 2A, Implementation of QA Criteria & 10 CFR 50.59 for AMT Components.
- FRN - scheduled publication Dec. 10, 2020. Document 2020-26845; Docket ID NRC-2020-0253.
- Public meeting planned for January 2021.

Assessment of Regulatory Guidance (Subtask 2B)

- Standard Review Plan (SRP) provides regulatory guidance to NRC technical reviewers regarding a large range of core regulatory areas.
- Focused on SRP sections and regulatory guides applicable to material engineering reviews.
- Staff concluded that there were no impediments in current regulations or regulatory guidance that were reviewed.
- Future consideration of updating existing regulatory guidance or developing additional regulatory guidance may help improve the efficiency and effectiveness of the staff's review and provide clearer expectations to the applicants for AMT submittals with regards to material properties and functions.
- Complete: ML20233A693

AMT Application Guidelines Framework (Subtask 2C)

- Develop a report providing guidelines which describe the generic technical information to be addressed in AMT submissions.
- Public meeting discussing initial framework was held July 30, 2020:
  - https://www.nrc.gov/pmns/mtg?do=details&Code=20200816.
- Meeting summary: ML20240A077.
- Framework document has evolved further into a draft document.
- Future public comment period, public meeting on the draft document.

AMT Application Guidelines Framework (Subtask 2C)

- 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.

General Review Philosophy

- Framework and associated guidelines 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 and QA/design controls
  - Subtask 2A of AMT Action Plan, rev. 1
  - Draft 2A document will be available for public comment Dec. 10, 2020
  - FRN Document Number 2020-26845
  - Docket ID NRC-2020-0253
- 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

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)

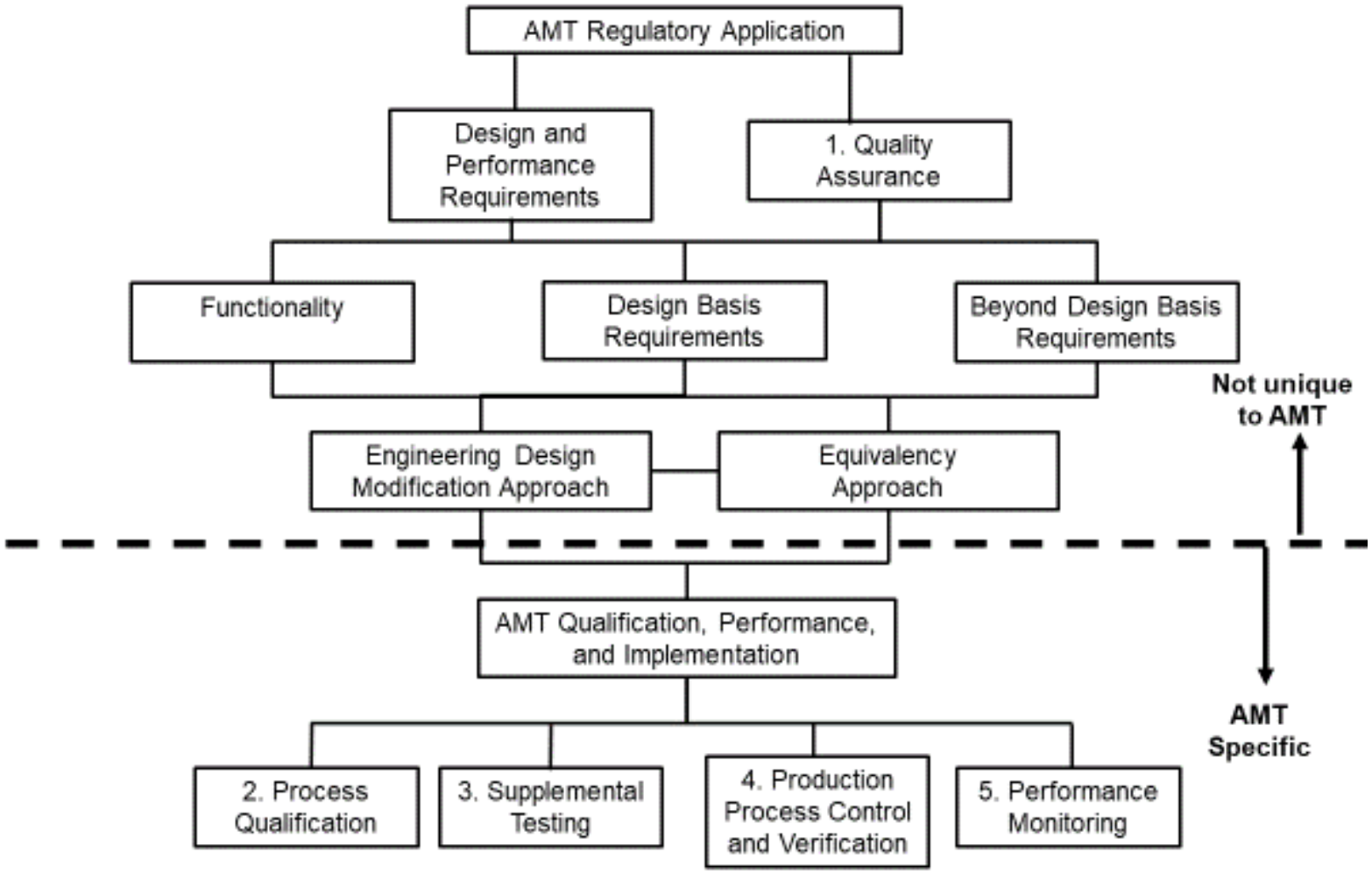
- An applicant must demonstrate that compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.
- Example: ASME Code Class 2 or 3 pump can no longer remain in service due to a degraded pump case housing 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.

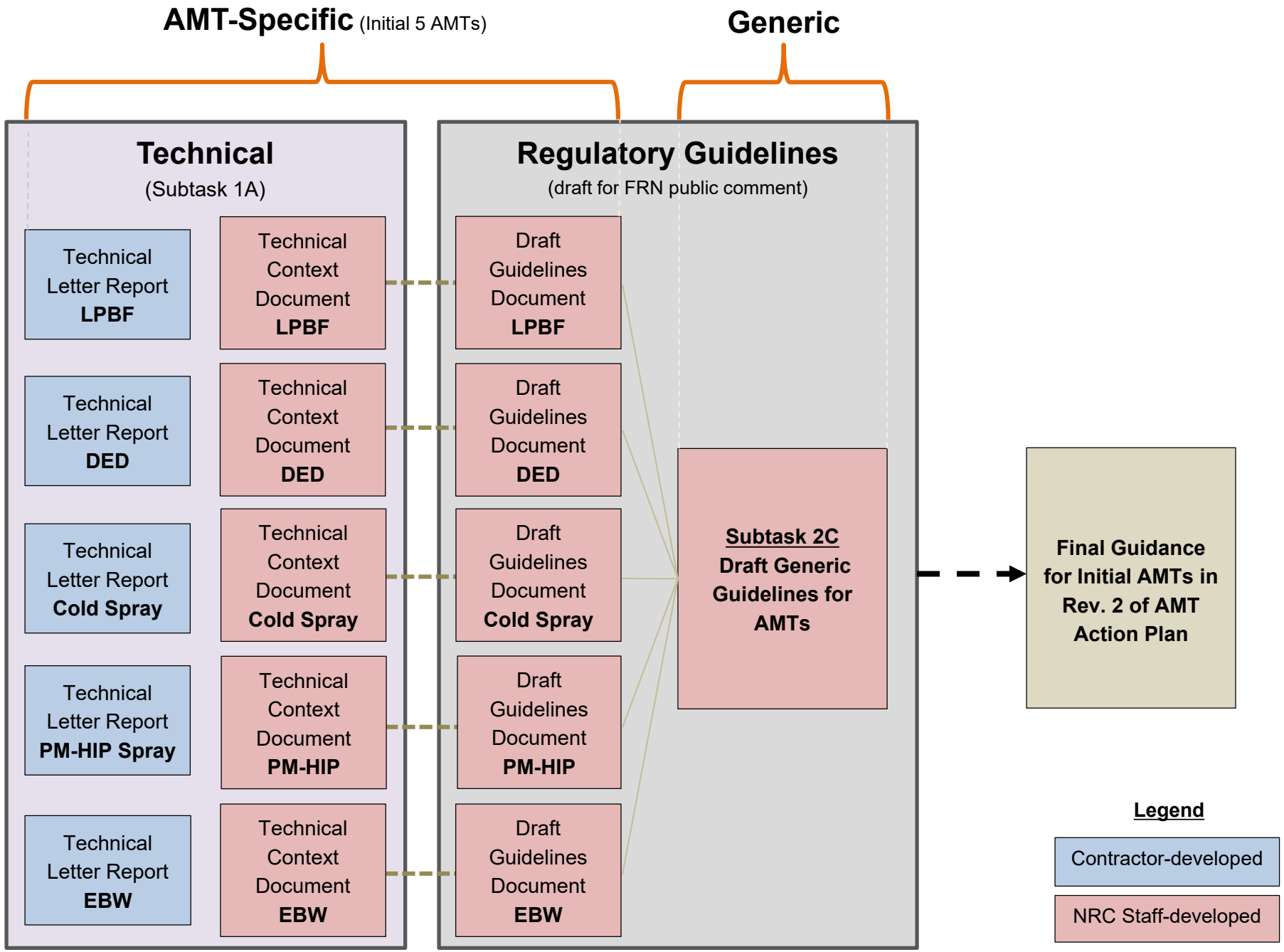
Process Flow Chart

The process flow chart in Appendix A to the AMT Application Guidelines 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-Specific (Initial 5 AMTs)
Generic
Technical
(Subtask 1A)
Regulatory Guidelines
(draft for FRN public comment)
Technical Letter Report LPBF
Technical Context Document LPBF
Draft Guidelines Document LPBF
Technical Letter Report DED
Technical Context Document DED
Draft Guidelines Document DED
Technical Letter Report Cold Spray
Technical Context Document Cold Spray
Draft Guidelines Document Cold Spray
Technical Letter Report PM-HIP Spray
Technical Context Document PM-HIP
Draft Guidelines Document PM-HIP
Technical Letter Report EBW
Technical Context Document EBW
Draft Guidelines Document EBW
Subtask 2C Draft Generic Guidelines for AMTs
Final Guidance for Initial AMTs in Rev. 2 of AMT Action Plan
Legend
Contractor-developed
NRC Staff-developed

Questions

Acknowledgements:

AMT Project Team: NRR – Carolyn Fairbanks, Bob Davis, Isaac Anchondo-Lopez; RES – Matt Hiser, Mark Yoo

AMT Technical Advisory Team: NRR – Allen Hiser, Dave Rudland; RES – Rob Tregoning

AMT Steering Committee: NRR – Hipo Gonzalez; RES – Steve Frankl, Raj Iyengar

NRC Staff: Meg Audrain, Chris Sydnor, Dave Beaulieu, Dong Park, Dan Widrevitz