

Regulatory Preparations for Advanced Manufacturing Technologies (AMTs)

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Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission

Advanced Materials & Manufacturing Technologies (AMMT) Industry Workshop
Oak Ridge National Laboratory
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U.S. Nuclear Regulatory Commission

- Licenses and regulates the civilian use of radioactive materials (reactors, nuclear materials, waste)
- Overall responsibility: Protect Public Health and Safety
 - Establish standards and regulations
 - Issue licenses
 - Inspect facilities and users of nuclear materials

Goal: Proactively prepare for efficient, effective, and transparent regulatory reviews of AMT submissions



NRC AMT Action Plan

(ADAMS ML19333B980)

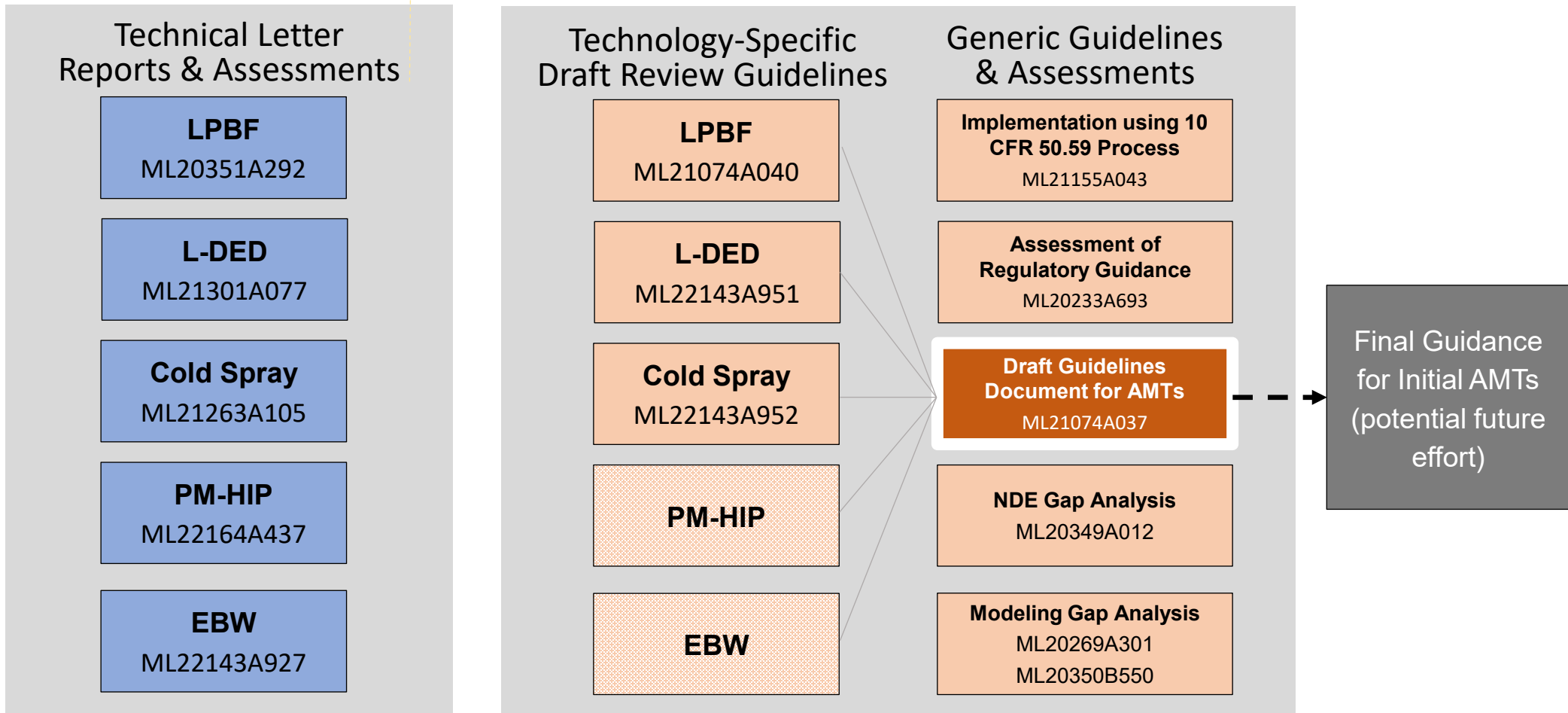
- Technical Preparedness
 - Technical Letter Reports (National Laboratories)
 - NRC Technical Assessments
- Regulatory Preparedness
 - Draft Guidelines Documents – *technology specific*
 - Draft Review Guidelines - *generic*
- Communications and Knowledge Management
 - Engagement with industry, codes & standards, research organizations, international
 - Staff development

NRC's initial focus areas

- Laser powder bed fusion (LPBF)
- Laser direct energy deposition (L-DED)
- Cold spray (CS)
- Electron beam welding (EBW)
- Power metallurgy—hot isostatic pressing (PM-HIP)

*new reactor fuel technologies are addressed outside the AMT Action Plan

Action Plan Products



General Review Philosophy

Two conventional paths to demonstrate that a 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)
- **Design Modification:** Technical justification for changing existing requirements (e.g., the original material provided significant margin compared to what is necessary for the component to meet its intended function)

Regulatory Pathways



Rulemaking

Title 10 of the Code of Federal Regulations (10 CFR)



License amendment

Technical specification change or other regulatory controls



10 CFR 50.59 Changes, tests and experiments

Establishes regulatory threshold for changes without a licensing action



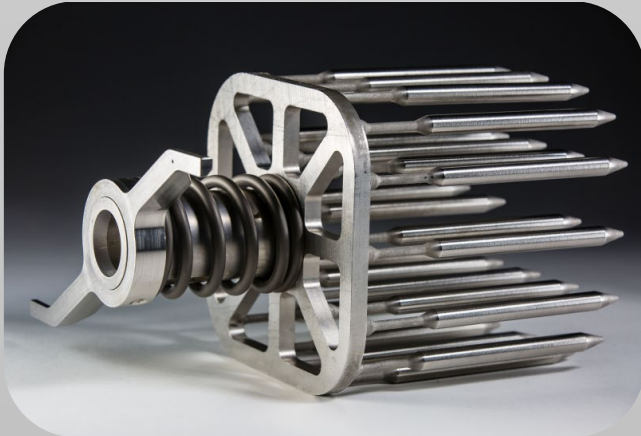
10 CFR 50.55a Codes and Standards

Endorsement of Code edition and Code cases; Alternatives

Examples of U.S. Applications *installed under 10 CFR 50.59*

Thimble Plugging Device

- Byron Unit 1
- 316L stainless steel – LPBF
- Non ASME B&PV Code class



Credit: Westinghouse

Channel Fastener

- Browns Ferry Unit 2
- 316L stainless steel – LPBF
- Non ASME B&PV Code class



Credit: Framatome

Implementation via Standards

The NRC has been directed by Congress to collaborate with standards-setting organizations to:

- identify specific technical areas for which new or updated standards are needed to support the commercial advanced nuclear reactor licensing process and
- incorporate the respective consensus-based codes and standards into the regulatory framework

- *Nuclear Energy Innovation and Modernization Act (NEIMA)*
- *National Technology Transfer and Advancement Act (NTTAA)*

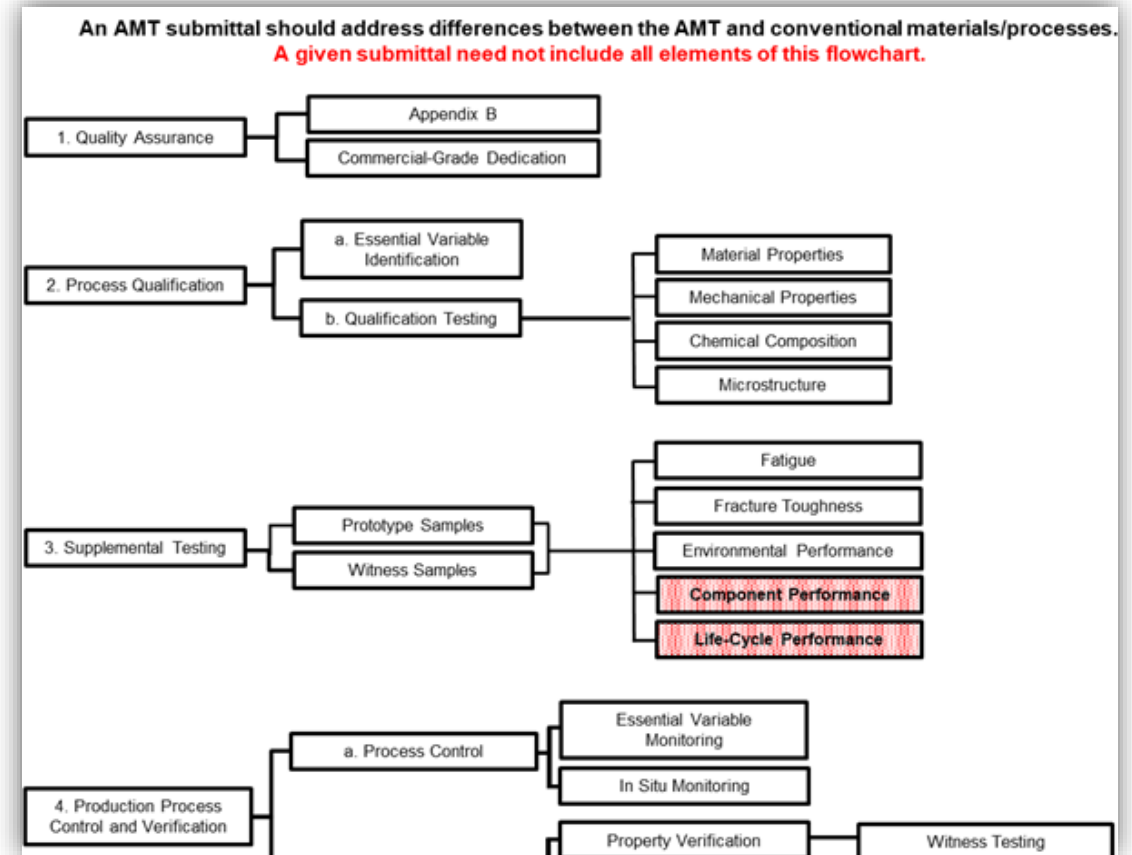
NRC Staff Codes and Standards Activities

- ASME Special Committee on Use of Additive Manufacturing for Pressure Retaining Equipment
 - Developed criteria qualification document for LPBF - ASME PTB-13 – plans to add DED
 - 316L LPBF Data Package and Code Case under development
 - Arc DED Data Package and Code Case under development – multiple materials
- ASME Section III Working Group on Advanced Manufacturing
 - Developing rules for fabrication of AM items, including support of AM Code Cases and new Section III Appendix for materials produced by AM processes
 - Process groups: PM-HIP, DED, QA Requirements
- ASME Section III Division 5 Task Group on Advanced Manufacturing for High Temperature Applications
 - Developing Code actions for incorporating AM materials/components in ASME Section III, Division 5
 - First application is PM-HIP

Alternatives to Codes and Standards

- Approval via other regulatory pathways is expected to be informed by general Code expectations, as well as:
 - Maturity of the technology
 - Precedent
 - Safety significance
- Vendors and licensees are encouraged to engage early with the NRC to discuss expectations

Excerpt from NRC Draft Guidelines Document



NRC Activities – Moving Forward

- Research
 - NDE confirmatory efforts on AMT components, mock-ups, welds
 - Assessment of additional technologies: Arc DED and diode laser cladding
 - Evaluation of long-term performance, including environmental effects (e.g., irradiation, corrosion)
- Participation in ASME Code activities
- NRC AMT Workshop: October 24-26, 2023

NRC Workshop on Advanced Manufacturing Technologies for Nuclear Applications

Save the Date
October 24-26, 2023
Rockville, MD

Objectives: Update all stakeholders on:

- practical experience and future plans for implementing AMT components / technologies
- AMT process/part qualification and certification approaches, including the incorporation of modeling and simulation
- latest developments in regulatory approaches, codes, and standards

AMTs of Interest Include (but are not limited to)		
Laser Powder Bed Fusion	Directed Energy Deposition	Cold Spray
PM-HIP	Electron Beam Welding	Hybrid Manufacturing
Laser Diode Cladding		
Materials of Interest Include (but are not limited to)		
Stainless Steels	Nickel Alloys	Low Alloy Steels

Final Perspectives

- Successful regulatory review preparations are highly dependent on awareness of industry interests, developments and advances
 - A few parts have been introduced into US plants using the 10 CFR 50.59 process
 - AMTs do not appear to be a high priority for safety related components in the current US LWR fleet
 - Potential interest for small modular and advanced reactors
- Codes and standards development is a key enabler
- Limited data is a challenge, especially environmental effects
- Effective and reliable NDE is critical to qualify and monitor the integrity of components



NRC Chair – visit to Advanced Manufacturing Pilot Facility at Georgia Tech

NRC Points-of-Contact & Additional Information

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NRC AMT website

<https://www.nrc.gov/reactors/power/amts.html>

Thank you

