

Industry / NRC Materials Programs Technical Information Exchange

Advanced Manufacturing Technologies Action Plan, Rev. 1

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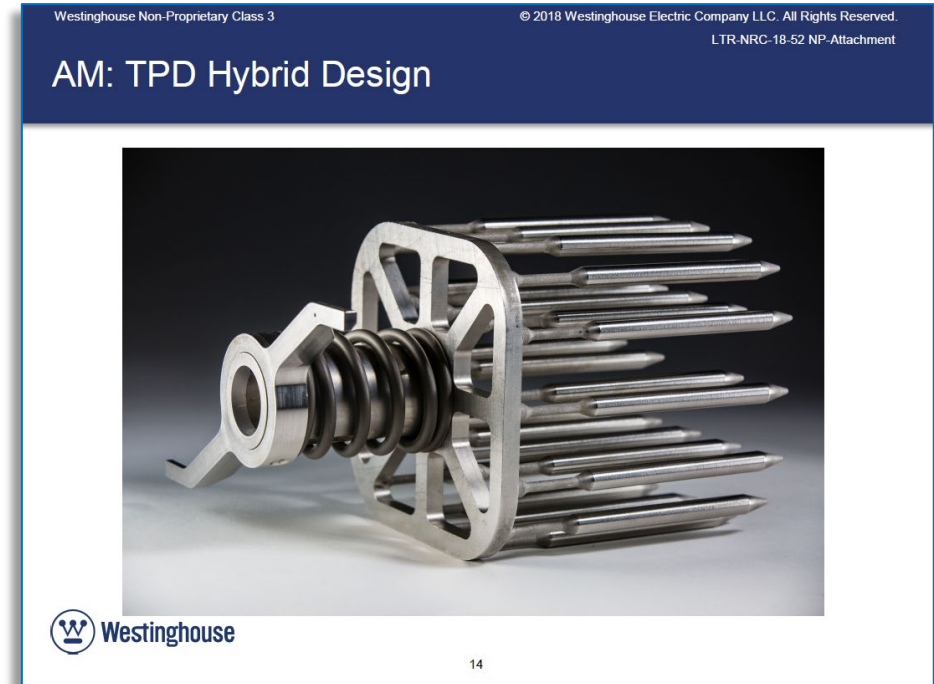
May 25-26, 2022

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
 - AMTs can include new ways to fabricate or join components, surface treatments, or other processing techniques to provide a performance or operational benefit.
- Initial AMTs based on industry interest:
 - Laser Powder Bed Fusion (LPBF)
 - Laser Direct Energy Deposition (L-DED)
 - Cold Spray
 - Electron Beam Welding
 - Powder Metallurgy - Hot Isostatic Pressing (PM-HIP)

First US Application of AMTs

- Thimble Plugging Device
 - Installed in March 2020 in Byron
 - 316L stainless steel -LPBF
 - Very low safety significant component (Non ASME B&PV Code class)
 - PWR environment with irradiation
 - Installation done without prior NRC approval under Title 10 of the Code of Federal Regulations (10 CFR) 50.59



Second US Application of AMTs

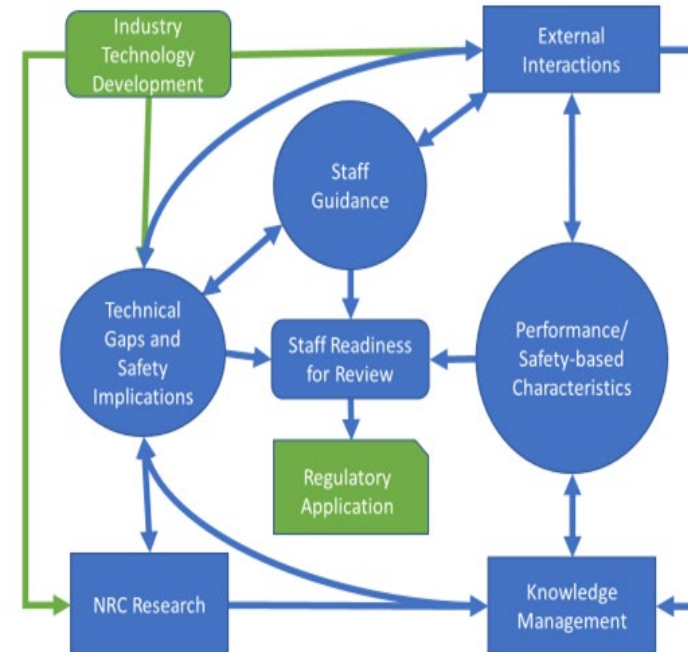
- Fuel assembly hardware
 - Installed in Spring 2021 in Browns Ferry
 - ORNL printed Framatome's winged channel fastener body
 - 316L stainless steel – LPBF
 - 4 will be installed, harvesting one each cycle from 2023-2027



https://www.ornl.gov/news/additively-manufactured-components-ornl-headed-tva-nuclear-reactor?utm_source=miragenews&utm_medium=miragenews&utm_campaign=news

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
 - Guidelines 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
 - 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

Subtask 2C: AMT Guidelines Document

- Develop guidelines which describe the generic technical information to be addressed in AMT submissions
- Public meeting September 16, 2021

Communications and Knowledge Management (Task 3)

Public Workshop on AMTs for Nuclear Applications

Location/Dates: Virtual, December 7-10, 2020

Objectives

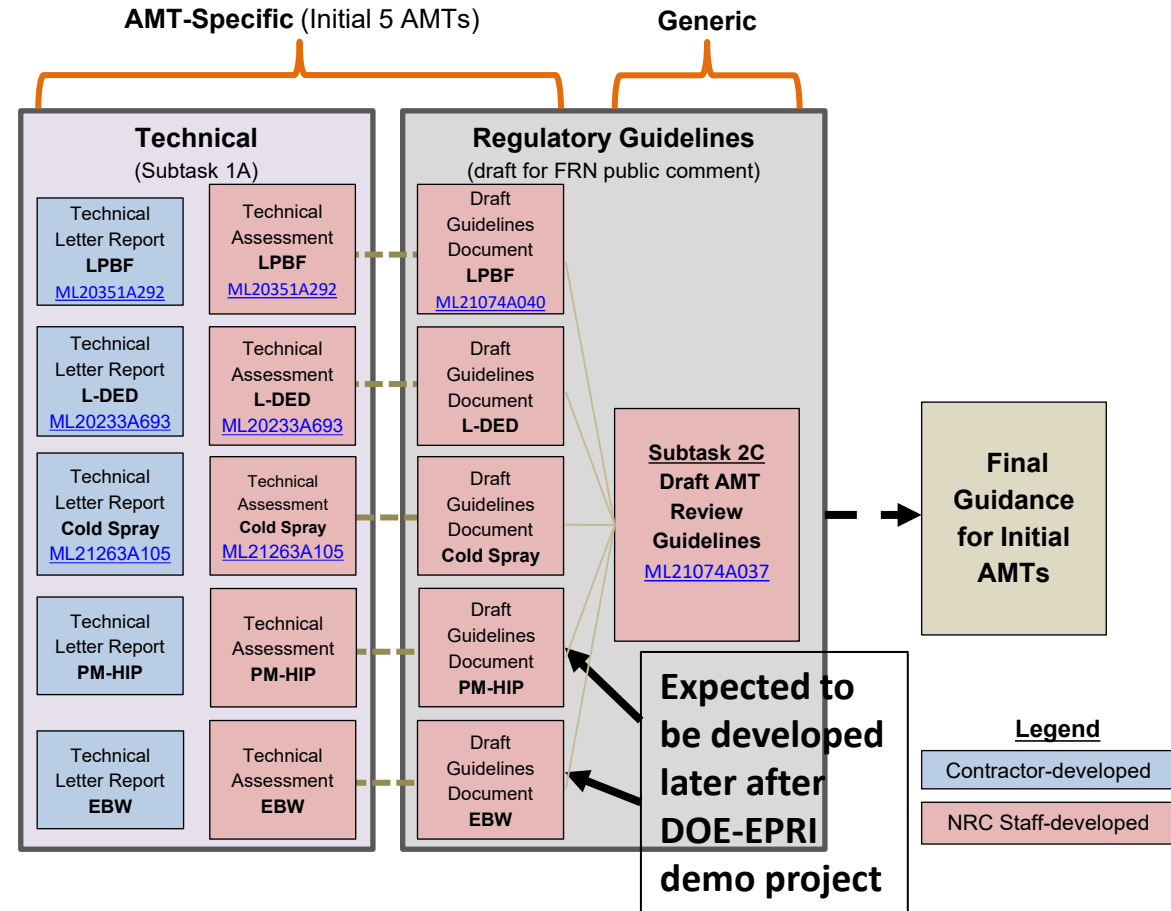
- Discuss ongoing activities related to AMTs, including nuclear industry implementation plans, codes and standards activities, research findings, and regulatory approaches in other industries.
- Inform public of NRC's activities and approach to approving use of AMTs.
- Determine, with input from nuclear industry stakeholders and other technical organizations, areas where NRC should focus to ensure safe implementation of AMTs

Participants

- ASME, US DOE, NIST, FAA, NASA, FDA, EPRI, NEI, Westinghouse, GE Hitachi, Kairos, VRC Metal Systems, Exelon, ORNL, PNNL, ANL, INL

NRC AMT Guidelines Development

- A Technical Letter Report (TLR) is produced for each of the initial five AMTs
 - Provides technical basis information and gap analysis
 - Written by NRC contractor (to date, DOE labs)
- A technical assessment (TA) is produced for each TLR by NRC staff that provides the NRC staff perspective on key aspects of the AMT for safety and component performance
- A draft guidelines document (DGD), informed by the TA and TLR, will be generated by the NRC staff for each AMT.
 - The AMT-specific DGDs accompany and align with the generic Advanced Manufacturing Technologies Review Guidelines



Status of Deliverables – Task 1

Subtask	Actions/Deliverables	Status
1A AMT processes under consideration	Additive Manufacturing (AM) – Laser Powder Bed Fusion	Complete - ML20351A292
	AM – Directed Energy Deposition (DED)	Complete - ML20233A693
	Cold Spray	Complete - ML21263A105
	Powder Metallurgy (PM) – Hot Isostatic Pressing (HIP)	Complete
	Electron Beam (EB) welding	Complete
1B Inspection and NDE	PNNL NDE gap analysis	Complete - ML20349A012
1C Modeling and Simulation of Microstructure	ANL M&S gap analysis to predict microstructure	Complete - ML20269A301
	ANL M&S gap analysis to predict material performance	Complete - ML20350B550

Status of AMT Draft Guidelines Development

Guideline Topic	Status
AMTs	Draft guidelines discussed at Sept. 16 public meeting: ML21074A037 - Draft AMT Review Guidelines ML21074A040 - Draft Guidelines Document for AM – LPBF
Additive Manufacturing (AM) – Laser Powder Bed Fusion	
AM – Directed Energy Deposition (DED)	Draft guidelines complete
Cold Spray	Draft guidelines complete
Powder Metallurgy (PM) – Hot Isostatic Pressing (HIP)	Draft guidelines not being developed at this time due to the state of these technologies and a specific ongoing research program to demonstrate their viability led by EPRI.
Electron Beam (EB) welding	

Status of Deliverables – Tasks 2 and 3

Subtask	Actions / Deliverables	Status
2A 50.59 process	Finalize document incorporating feedback from Regional staff regarding the 10 CFR 50.59 process	Complete – ML21200A222
2B Assessment of regulatory guidance	Path forward on guidance development or modification	Complete - ML20233A693
2C AMT Guidance Document	Public meeting on guidance concept / framework	summary: ML20240A077
	Develop a document that describes the generic technical information to be addressed in AMT submittals.	Public meeting held on September 16, 2021 to discuss:
	Public meeting to discuss draft document	ML21074A037 - Draft AMT Review Guidelines ML21074A040 - Draft Guidelines Document for AM – LPBF
3D Workshop	Hold Public Workshop	Complete – summary: ML20357B071 RIL: Part 1 Part 2

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