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# Regulatory Development for Advanced Manufacturing

September 2021

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**September 2021**

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**INL ART Program**

# Regulatory Development for Advanced Manufacturing

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# ABSTRACT

Advanced Methods of Manufacturing (AMM) are new, novel manufacturing processes that have the potential to bring significant cost and schedule reductions to many industries, including the nuclear industry. These methods produce components faster and more cheaply than many traditional methods. This includes replacing obsolete components at currently operating plants as well as manufacturing components of all sizes for advanced reactors.

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# ACRONYMS

| | |
|---|---|
| AMM | advanced method of manufacturing |
| AR | advanced reactor |
| ASME | American Society of Mechanical Engineers |
| DOE | Department of Energy |
| FY | fiscal year |
| INL | Idaho National Laboratory |
| LAR | License Amendment Request |
| NEI | Nuclear Energy Institute |
| NRC | Nuclear Regulatory Commission |
| NTD | National Technical Director |

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# Regulatory Development for Advanced Manufacturing

## 1. PURPOSE

Advanced Methods of Manufacturing (AMMs) are novel manufacturing processes that have the potential to bring significant cost and schedule reductions to many industries, including the nuclear industry. These methods produce components faster and less expensively than many traditional methods. This includes replacing obsolete components at currently operating plants as well as manufacturing components of all sizes for advanced reactors (ARs).

Currently, many companies are developing processes and pursuing the use of these products in the nuclear industry. Up to now, a significant lack of clarity obfuscated regulatory pathways and approval processes. The U.S. Nuclear Regulatory Commission (NRC) has been working for the past four years to learn about these manufacturing processes and prepare for the industry to submit requests for approval of the use of products manufactured by AMMs. The NRC continues to follow its action plan to learn about the technologies and prepare for their use in the nuclear industry.

During Fiscal Year (FY) 2020, Idaho National Laboratory (INL) staff determined a need to provide regulatory-strategy support to the Department of Energy (DOE), industry, and the AMM team. Because of funding allowances, INL staff added a task to provide support to the AMM team. This task continued into FY 2021, when a majority of the work was to be performed.

The purpose of the task is to provide industry with regulatory-strategy support to the AMM national technical director (NTD), and in coordination with related NRC efforts associated with AMM. Currently, INL staff supports the development of an AMM roadmap, which is being developed through the AMM NTD. This roadmap will be the basis for DOE actions in AMM and will be important to assisting INL staff in developing future activities to support industry to adopt of AMMs. Currently, the roadmap is delayed due to a slowing of industry research and collaboration due to COVID-19 and codes and standards activities. This activity will continue into FY 2022; however, regulatory support will be funded directly through the AMM program funding rather than funding from regulatory development.

## 2. OBJECTIVES

The objective of this task is to work with the Nuclear Energy Institute (NEI), industry, and the DOE's AMM program to provide regulatory support for the development of AMM processes and the use of AMM products in the nuclear industry. While this specifically supports ARs, the regulatory pathways identified during this support task will also be used to support the current operating fleet as well as small modular reactors and others, where applicable.

The second objective of this task is to work with the AMM NTD to provide regulatory development and support for the development of the AMM roadmap. This roadmap will be the basis for future development and deployment of AMMs in DOE's Office of Nuclear Energy. INL staff is also working with NEI and industry to support codes and standards efforts that directly lead to NRC regulatory approval.

Additionally, INL regulatory staff supported the planning and holding of a workshop on AMM and will continue supporting the planning of a second that will be held in-person. The first of these workshops was virtual and held on August 24–25, 2021. The second is planned to be in-person in October, but this workshop may move depending on the status of restrictions for COVID-19.

## 3. SUMMARY OF COMPLETED WORK

INL regulatory staff have supported the DOE-AMM program and the AMM NTD in many ways during FY 2021. This support has been entirely virtual due to the COVID-19 restrictions.

During FY 2021, INL regulatory staff have supported the initial development of the AMM Roadmap. This support has included briefing the group on regulatory processes, developing flowcharts, and reviewing documentation developed by industry, NEI, and NRC. The review of these documents was reported to the AMM team to support their work.

## 3.1 Regulatory Pathways

INL regulatory staff provided detailed guidance on regulatory pathways for NRC acceptance of AMM-made products. The most important guidance came by reviewing NEI's 2019 report entitled "Roadmap for Regulatory Acceptance of Advanced Manufacturing Methods in the Nuclear Industry."[1] One of the most-important flowcharts, shown in Figure 1, is from this document, and outlines the three possible pathways to gaining regulatory acceptance.

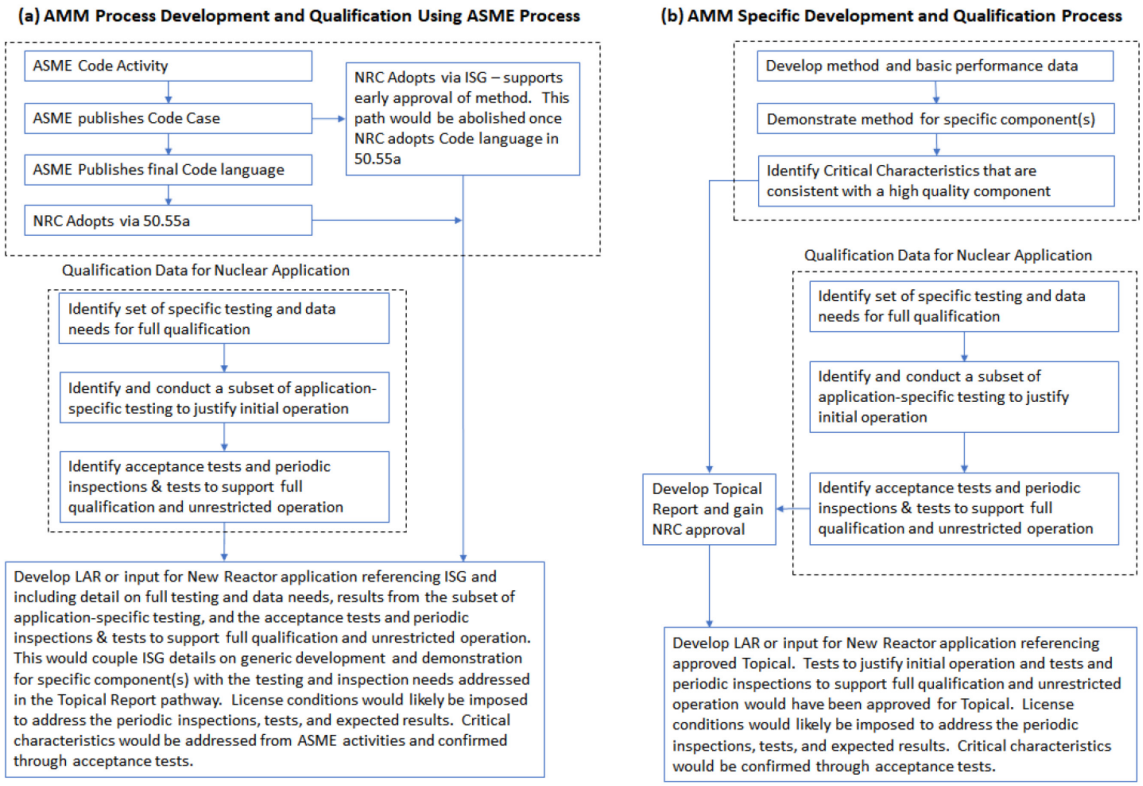


Figure 1. Pathways to Gaining Regulatory Approval for AMM Components.[1]

The first pathway to acceptance of an AMM-made product would be through an American Society of Mechanical Engineers (ASME) code activity. An organization would develop the ASME Code Case and submit it to the proper committee for review and acceptance. Upon approval, there are two options. The first option would be for ASME to publish the Code Case in final code language. The NRC could adopt the code edition via 10 Code of Federal Regulations (CFR) 50.55a. The second option would involve the NRC's issuing interim staff guidance (ISG) about the approved Code Case. The ISG would be abolished once the NRC accepted the code language in 10 CFR 50.55a. Either of these two options would require a licensee to develop a license amendment request (LAR) or an applicant to provide input into a new reactor application.[1]

The second option would be for an organization to develop a full set of qualification data for an AMM in a nuclear application. This would require significant testing and data collection. A licensee could then apply using an LAR, or the applicant could develop input on a new reactor application.[1]

The third option is a more-specific development and qualification process. A stakeholder would develop a topical report and submit it to the NRC for approval. Similar to the second option, this topical report would require a full set of qualification data but would also require the development of performance data and critical characteristics that are "consistent with a high-quality component." This information would be used to develop the topical report. This topical report would be submitted to the NRC and, upon approval, a licensee could submit an LAR for the use of this component.

In any of these cases, the NRC is likely to impose significant periodic inspections and testing to verify critical characteristics and ensure the component meets standards for the duration of its life.

## 3.2 AMM Workshops

INL regulatory staff have supported the planning of a series of AMM workshops for the fall of calendar year (CY) 2021. The first of these workshops was held August 24–25, 2021 and was held virtually on the GoToWebinar platform. The second workshop is scheduled to be held in person during October 2021. This could be delayed due to the COVID-19 restrictions placed on DOE and national laboratories.

The first workshop included presentations from individuals from all sides of the AMM world, including:

- Codes and standards representatives from ASME and American Society of Testing and Materials (ASTM), including presentations on how materials are qualified within the ASME code
- U.S. NRC
- Electric Power Research Institute (EPRI)
- Corporate stakeholders
- Advanced Reactor Technology Working Group leads
- National laboratory partners.

These presentations were separated into multiple sections over two days that relate directly to major AMM needs. These include:

- Current Standards for Materials and Component Qualification and the Regulatory Process
- Digital Threads and Modeling (Databases of Properties)
- Supply Chain Opportunities and Challenges
- Lessons Learned – Success Stories – Accomplishments
- Nuclear Industry/ End User Feedback and AMM needs."

These were followed by a longer session of brainstorming between the workshop presenters and the attendees. This brainstorming session is expected to identify the major qualification issues that impact commercialization and to identify opportunities to accelerate commercialization. The items identified in this brainstorming session will directly support the development of the second workshop. That workshop will be in person and will include opportunities to meet stakeholders, see AMM laboratories and equipment, and define achievable goals to accelerate the commercialization of AMMs.

# 4. NEXT STEPS

Regulatory work for the AMM program was delayed in FY 2020 due to slower progression in the AMM program than was anticipated. COVID-19 restrictions impacted and delayed the development and hosting of the AMM workshops and progress on the AMM Roadmap, including the regulatory section. However, INL regulatory staff were able to provide detailed regulatory pathways for NRC acceptance of an AMM-made product for use in a nuclear power plant, including new reactors. INL regulatory staff continue to support the AMM team on the development of the AMM Roadmap as well as supporting the hosting of workshops to gather information on AMM commercialization paths. This activity will not continue into FY 2022 under the regulatory-development area. INL regulatory staff will support development of the AMM Roadmap using resources provided by the AMM Program.

# 5. REFERENCES

[1] NEI, "Roadmap for Regulatory Acceptance of Advanced Manufacturing Methods in the Nuclear Energy Industry", www.nei.org, May 13, 2019.

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# Appendix A
# AMM Qualification Workshop Agenda (Draft)

## AGENDA

**Tuesday, August 24, 2021**

| Time (EDT) | Setting the Stage | Presenter |
|---|---|---|
| **11:00 a.m.** | **Welcome / Workshop Overview / Virtual Meeting Logistics** | **Isabella Van Rooyen, INL** |
| 11:10 a.m. | Industry Collaboration (GAIN, EPRI, NEI) | Lori Braase, GAIN<br>Andrew Sowder, EPRI<br>Everett Redmond, NEI |
| 11:25 a.m. | DOE-NE AMM Program | Dirk Cairns-Gallimore, DOE-NE |
| 11:35 a.m. | Setting the Stage: Future Opportunities | Isabella Van Rooyen, INL |
| | **Current Standards for Materials and Component Qualification, and the Regulatory Process** | **Dave Gandy, EPRI** |
| 11:50 a.m. | • "Big Picture View" | Jason Christensen, INL |
| 12:00 p.m. | • ASME BPV II Materials – Conventional ASME Materials Qualification | Jay Cameron, HSB |
| 12:25 p.m. | • ASME BPV-III Division 5 – High Temperature Nuclear Materials Qualification | Richard Wright, INL |
| 12:50 p.m. | • ASME BPV-III MF&E Advanced Manufacturing and Qualification | Daniel Mann, Flowserve |
| 1:10 p.m. | • NRC Perspective | Robert Davis, US NRC |
| **1:30 p.m.** | **Break** | |
| 1:45 p.m. | • ASME Non-Metallics Materials Working Group Activities | Kate Hyam, ASME |
| 2:05 p.m. | • ASTM Standards Overview | Shane Collins, ASTM |
| **2:15 p.m.** | **Q&A / Discussion** | |
| | **Digital Threads and Modeling (Databases of Properties)** | **Ram Devanathan, PNNL**<br>**Ed Herderick, OSU** |
| 2:35 p.m. | • Demonstration of Digital Threads Application | Ryan DeHoff, ORNL |
| 2:50 p.m. | • Machine Learning | Mohammad Abdo, INL |
| 3:05 p.m. | • Digital Thread Factory – Metrology, Quality, and Modeling | TBD |
| 3:20 p.m. | • Digital Thread for Additive Manufacturing and Nuclear Case Study | Tim Bell, Siemens |
| 3:35 p.m. | • Design, Fabrication and Testing of Scaled Components | Per Peterson, Kairos |
| **3:50 p.m.** | **Q&A / Discussion** | |
| **4:10 p.m.** | **Closing Remarks** | Isabella van Rooyen, INL |

# AGENDA

**Wednesday, August 25, 2021**

| Time (EDT) | "Real Life" Application and Capability | Presenter |
|---|---|---|
| **11:00 a.m.** | **Welcome / Roadmap(s) Overview** | **Isabella Van Rooyen, INL** |
| | **Supply Chain Opportunities and Challenges** | **Marc Albert, EPRI** |
| 11:10 a.m. | • Opportunities & Challenges in AMM Procurement | Jason Hurst, Nuscale Power |
| 11:25 a.m. | • Opportunities & Challenges in AMM Component Qualification and Supply | Teresa Melfi, Lincoln Electric |
| 11:40 a.m. | • Supplier Challenges | Christine Burow, KSB |
| 11:55 a.m. | • Qualifying Additively Manufactured Advanced Reactor System Parts | Derek Rountree, Luna Innovation |
| 12:10 p.m. | • Supply Chain Development and Qualification Processes | John Shingledecker, EPRI |
| 12:25 p.m. | • Microreactor Supply Challenges | Pavel Txvetkov, TAMU |
| **12:40 p.m.** | **Q&A / Discussion** | |
| | **Lessons Learned – Success Stories - Accomplishments** | **Ed Herderick, OSU** |
| 1:00 p.m. | • FOAK Deployment – Thimble Plug | Clint Armstrong, Westinghouse |
| 1:15 p.m. | • FOAK Deployment – Channel Fastener | Christopher Wiltz, Framatome |
| 1:30 p.m. | • ASME Code Case Development for 316L SS Using PM-HIP | David Gandy, EPRI |
| **1:45 p.m.** | **Q&A / Discussion** | |
| **2:00 p.m.** | **Break** | |
| | **Nuclear Industry / End User Feedback (Day 1 Presentations) and AMM Needs** (Materials, Components, Digital Systems, Supply Chain etc.) | **Hilary Lane, NEI** |
| 2:15 p.m. | • Molten Salt Reactors | Lauren Lathem, Southern Co. |
| 2:30 p.m. | • High Temperature Reactors | Farshid Shahrokhi, Framatome |
| 2:45 p.m. | • Fast Reactors | TBD |
| 3:00 p.m. | • Microreactor Unique Considerations and Relevant Needs | Holly Trellue, LANL |
| 3:15 p.m. | • Existing Fleet Component Testing and Relevant Needs | Lee Friant, Exelon |
| **3:30 p.m.** | **Q&A / Discussion** | |
| **3:50 p.m.** | **AMM Qualification Workshop – Part II: Brainstorming Sessions – November 4, 2021**<br>*(Proposed session topics, process/purpose/expected outcomes, teams, team leaders, etc.)*<br>• **What are the major materials qualification issues impacting commercialization?**<br>• **What are the opportunities to accelerate commercialization?** | |
| **4:30 p.m.** | **Adjourn** | |