

# Topics of Interest for Additive Manufacturing of Reactor Materials and Components

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# Topic Areas

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- Quality of AM materials and components for NPPs
- Codes and standards aspects of AM
- Properties and structural performance
- Service performance / aging degradation
- Cyber security

# But First – For NRC Planning Purposes

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- Schedule for industry implementation of AM
  - Topical report process
  - License amendment process
  - 10 CFR 50.59 process
  - Timing of plant-specific implementation vis-à-vis codes/standards action and/or topical report approval will significantly affect review complexity
- Volume of licensing actions
  - Could lead to prioritization of reviews
- Scope of actions that are of interest to NRC – similar to License Renewal
  - safety-related systems, structures, and components (SSCs)
  - all nonsafety-related SSCs whose failure could adversely impact functionality of safety-related SSCs
  - SSCs relied on in certain safety analyses or plant evaluations for specific NRC regulations.

# Quality of AM Parts for NPPs

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- AM Build Process
  - Critical parameters
  - Directionality
  - Uniformity
  - Residual stresses
  - Surface roughness
  - Density
  - Powder reuse
- Post-Build Processing
  - Densification (e.g., Hot Isostatic Pressing)
  - Annealing
  - Surface processing

# Codes and Standards Aspects of AM

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- American Society of Mechanical Engineers (ASME)
- ASTM International
  - formerly American Society for Testing and Materials
- American National Standards Institute (ANSI)
- American Society for Nondestructive Testing (ASNT)
- NACE International
  - formerly National Association of Corrosion Engineers

# Properties and Structural Performance

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- Properties
  - As-built
  - After post-build processing
  - Coupons vs. component
  - Fatigue performance
  - Comparison to conventional manufacturing methods
- Defect Characteristics/Populations
  - Type
  - Size
  - Density
  - Impact on structural integrity

# Properties and Structural Performance

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- Inspectability
  - In-process examinations
  - Methods capable of finding structurally relevant defects
  - Pre-service inspections
  - Inservice inspections

# Service Performance / Aging Degradation

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- In various service environments
  - Aqueous
    - Corrosion
    - Stress corrosion cracking (SCC)
    - Environmental fatigue life
    - Environmental fatigue crack growth
  - Neutron effects
    - Loss of fracture toughness
    - Swelling
    - IASCC
  - Thermal effects
    - Loss of fracture toughness
    - Thermal expansion



# Summary

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- Additive Manufacturing has been identified as an area of potential future utilization by the nuclear industry – “when” and “how many” are the questions
- NRC interest areas
  - The quality of AM parts
  - The properties of AM parts
  - The structural performance of AM parts, including their inspectability
  - The service performance and aging degradation of AM parts
- Codes and standards aspects of AM is a key to successful implementation
- Comparison of performance of parts from AM and conventional manufacturing process