Westinghouse eVinci™ Micro Reactor

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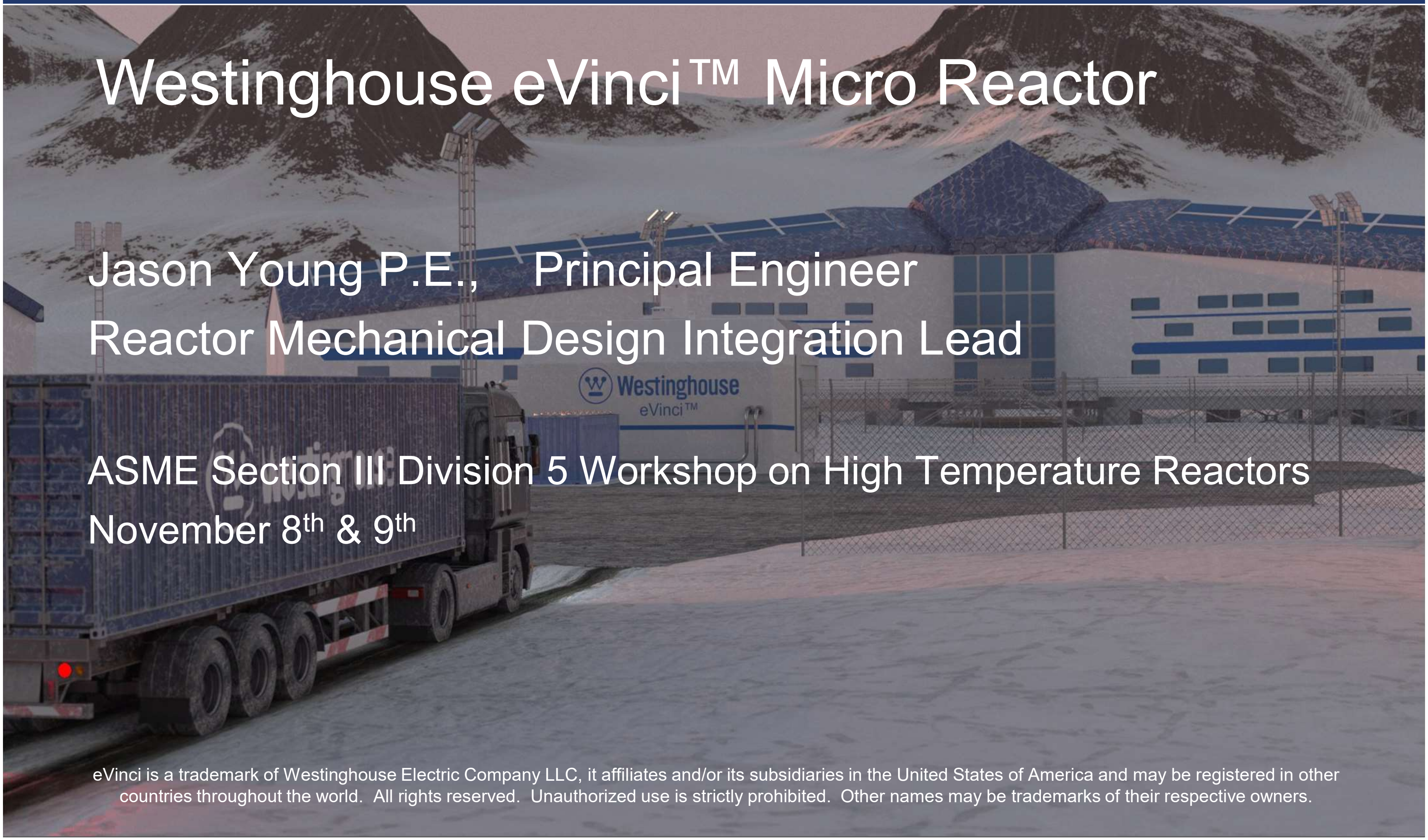
Reactor Mechanical Design Integration Lead

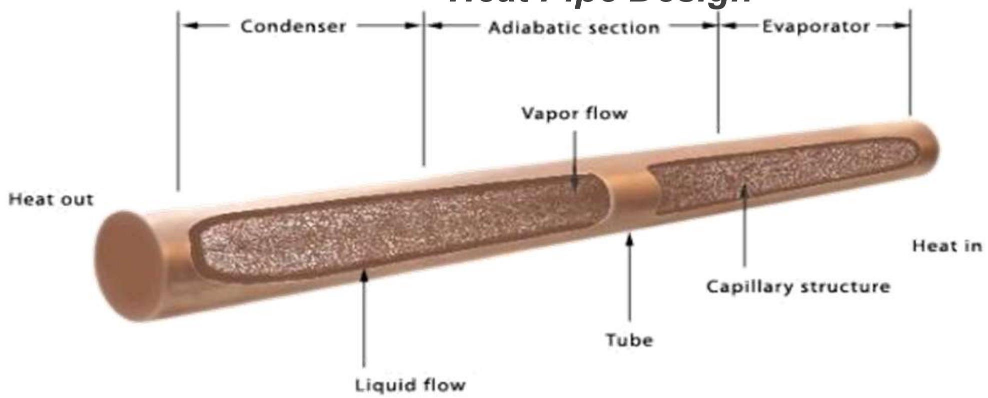
ASME Section III Division 5 Workshop on High Temperature Reactors

November 8th & 9th



eVinci Micro Reactor

Heat Pipe Design



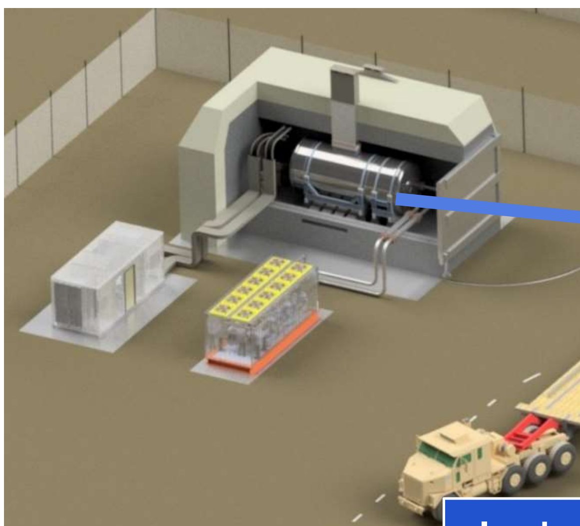
Solid State
Heat Pipe Reactor

Attributes

- 1-2 MWe mobile energy generator, and 4-5 MWe for transportable installations
- TRISO or Fuel Type is Flexible
- Heat Pipe Cooled
- Graphite Block Monolith
- Inert Gas Canister Blanket
- 800°C+ Temperatures
- Low Reactor Op. Pressure ~1 atm
- Fully factory built, fueled and assembled in modular transportable containers
- Passive heat pipe technology
- 40-year design life with 3+ years continuous power
- Inherent safety - no operator action or mechanical actuations
- Capable of providing high temperature process heat
- Zero emergency planning zone (EPZ)
- Small installation footprint

Incorporating Market Requirements

- Transportability – Standard Shipping Envelope
- Ease of Operation – Autonomous Control
- Battery Concept – Entire Reactor Replaced; No Onsite Refueling
- Adaptability of Design – Applicable for Both Heat and Power
- Driven by Economics – Competitive with Existing Power Sources



Industry Shifting Deployment Models

Reactor in a standard Modular Transportable Container

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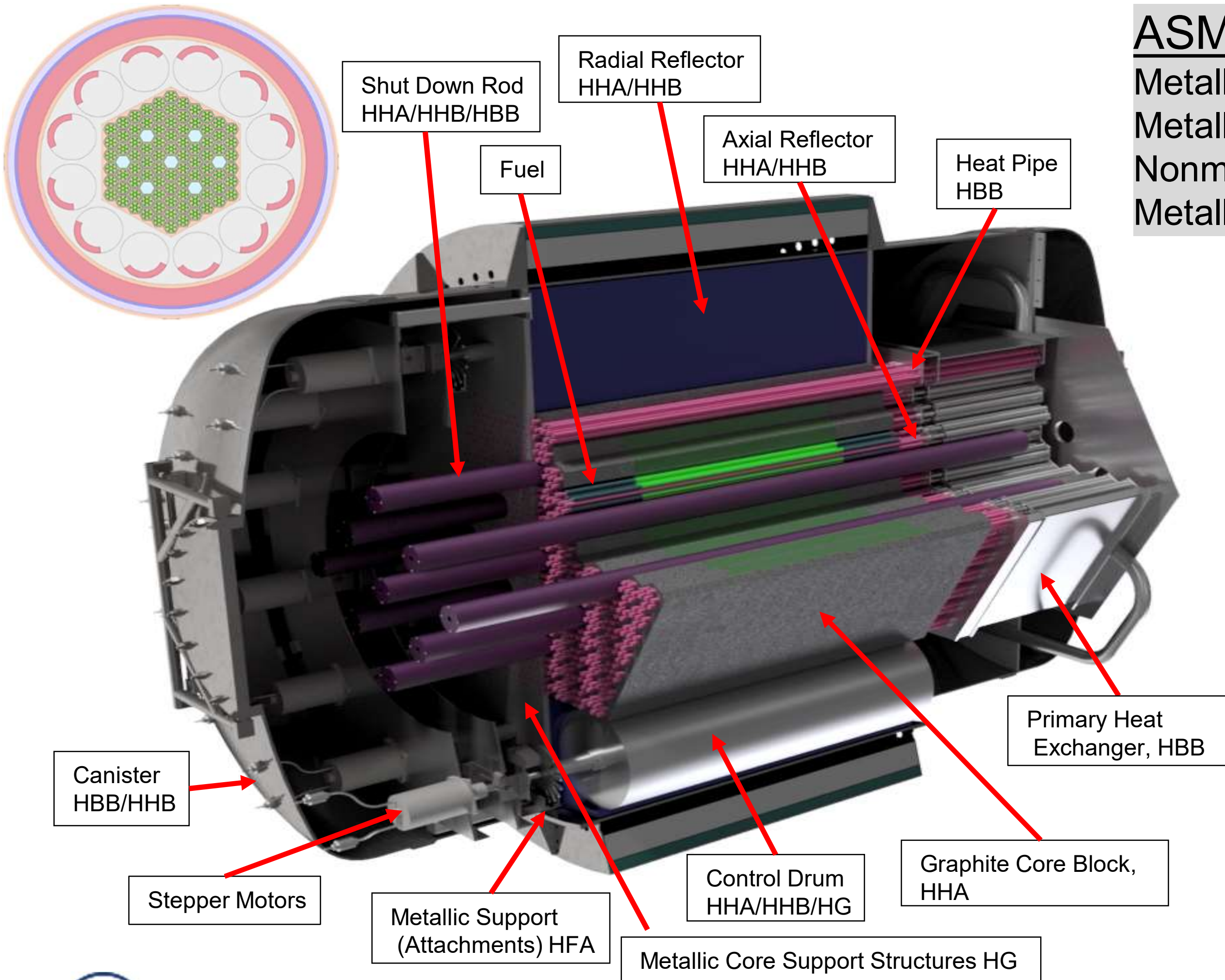
eVinci Technology, Partners & Classifications



ASME Code Classifications

Metallic Pressure Boundaries (HBB)
Metallic Core Supports (HGB)
Nonmetallic Core Components (HHA|HHB)
Metallic Supports (HFA)

Code Classifications

Material Classes

	Temperature	Radiation	Life
Stainless Steels	550-800°C	Relatively Low dpa per 3+ Continuous Operation Cycle	Multiple 3+ Years Continuous Operational Cycles Target Total Design Life* = 40 Years *Individual Component Design Life Targets Vary Depending on Number of Designed Continuous Operation Cycles
Super Alloy Steels	800°C+		
Heat Pipe Metallic Alloy	800°C+		
Graphite	800°C+		
Ceramic-Composites	800°C+		
Ceramic Core Components (Nuclear Materials)	800°C+		

Design Environments and Materials Exceed Current Code Material Data Sets

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Jurisdictional Boundary for Heat Pipe Reactors

- **Solid State Heat Pipe Reactor Components Differ from Current Code Geometries (ex. HTGR Geometries, HHA-1400)**

- **Clarify Jurisdictional Boundaries for Heat Pipe Reactors**
  - Canister Containment Boundaries
  - Heat Pipe Core Components
  - Core Restraint Component Geometries (Metallic | Ceramic)
  - High Temperature Mechanical Connections (Metallic | Ceramic)
  - Core Reactivity Control Components: Shutdown and Control Drum
  - Non-Prismatic Neutron Reflector Geometries
  - Structural Support of Shielding and Reflector Materials
  - Heat Exchanger Geometries

Heat Pipe Reactor Components Differ from Existing Code Geometries

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Code Application Topics

Code Enhancement Considerations

Topic	Consideration	Timeline	Priority
Classification | Jurisdictional Boundary for Heat Pipe Reactors (Applicability to Heat Pipe Reactors)	HHA-1400 Code Enhancement	Next Revision	High
Expand Material Data Sets (Common Shared Industry Materials: Ceramic-Composites, Ceramic Nuclear Materials, Heat Pipe Metallic Specialty Alloys)	HHB - Provide a Practical Strategy for Qualification of Loading Conditions for Anisotropic Ceramic-Composites, Expand Temperature | Time Material Data Throughout for Common Materials	<2-5 Years	High
Div5 Committee Interactions and Code Enhancements (HBB, HHA|HHB, HG, HF)	Future Potential Code Interpretation or Clarification Opportunities for Div5 as Design Progresses, Expansion of HF (Supports)	<1 Year	Medium
Evaluate Codes & Standards Gap Closure Deliverables (ex. NEI) (Evaluate New Guidance, As Available)	Key Areas: 1) Div5, 2) Functional Containment, 3) Material Data, 4) Section XI Inspection, 5) QME-1 Passive Equipment	Evaluate Per NEI Development Schedule	Medium
Canister Containment (Integrate High Temperature Containment Rules into Code Sections, Concept of Functional Containment)	Evaluate Value in Developing Containment Rules at High Temperature	Future Revisions	Low

eVinci Development Timeline

2020	2021	2025	2026
Electrical Demonstration	Nuclear Demonstration/ Prototype	Commercial Unit	

- Use Code as Design Guidance, Establish Preliminary Design
- Develop Material Properties, Use Code Material Specifications Sections
- Continually Evaluate, As Available: Code Revisions, NEI Code Gaps Closures, etc.
- As Necessary, Pursue Code Cases, Request Code Clarifications, etc.
- Finalize Design Using Code in Performance / Consequence Licensing Approach

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Leverage the Code During Design

eVinci Closing Summary
Slide 1 of 2

- **High Temp. Solid State Mobile Heat Pipe Micro-Reactor**
  - Diversity Relative to HTGR Limits Applicable Code Sections
- **Low Pressure Solid Design Leads to Simple Components**
  - Many Classical HTGR Div5 Components Do Not Apply Directly
- **Aggressive Schedule, Planned Full-Scale Demonstrations**
  - Challenge for Incorporation of Developing Codes and Standards
- **Temperatures, Materials Outside Existing Code Revisions**
  - Developing Properties Specific to High Temp Heat Pipe Reactors

Heat Pipe Micro-Reactor Present
Unique Code Considerations

eVinci Closing Summary
Slide 2 of 2

- **Functional Containment Concept Limits Core Components**
  - No Fuel Assy | Clad, Alternate Containment Barrier Classification
- **Leveraging Code as Practical when Directly Applicable**;
  - or when underlying principals broadly apply to new technologies
- **Utilize Code in Licensing Activities**
  - in a Consequence | Performance Based Licensing Approach

Heat Pipe Micro-Reactor Present
Unique Code Considerations

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More Info

http://www.westinghousenuclear.com/New-Plants/eVinci-Micro-Reactor