



Kairos Power

NIC2024


Hermes Reactor Technology Roadmap

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Micah Hackett received his M.S. and Ph.D. at the University of Michigan in nuclear engineering and has 16 years' experience working in the nuclear industry, nearly all in the advanced nuclear reactor industry. Since 2017 he has been leading the programs on materials and fuels development and qualification for Kairos Power's fluoride-salt-cooled high-temperature reactor (FHR). His work supports materials testing, qualification, and product development, tritium management strategies, development of non-destructive evaluation technologies for high-temperature reactor applications, fuel qualification, and fuel fabrication processes plus characterization of TRISO fuel. Previously, he worked in various programs on materials optimization, qualification, testing, manufacturing, and supply chain development for the sodium-cooled fast reactor design at TerraPower. He also worked on weld materials development and welding methods for Naval Reactors at the Knolls Atomic Power Laboratory, where he was awarded the 2009 Young Scientist of the Year Award.





Kairos Power's mission is to enable the world's transition to clean energy, with the ultimate goal of dramatically improving people's quality of life while protecting the environment.

In order to achieve this mission, we must prioritize our efforts to focus on a clean energy technology that is *affordable* and *safe*.

Overview of Kairos Power

- Nuclear energy engineering, design, and manufacturing company *singularly focused* on the commercialization of the fluoride salt-cooled high-temperature reactor (FHR)
 - Founded in 2016
 - ~400 Employees
- Novel approach to nuclear development that includes iterative hardware demonstrations and in-house manufacturing to achieve disruptive cost reduction and provide true cost certainty
- Schedule driven by US demonstration by 2030 (*or earlier*) and rapid deployment ramp in 2030s
- Cost targets set to be competitive with natural gas in the US electricity market

Kairos Power Headquarters

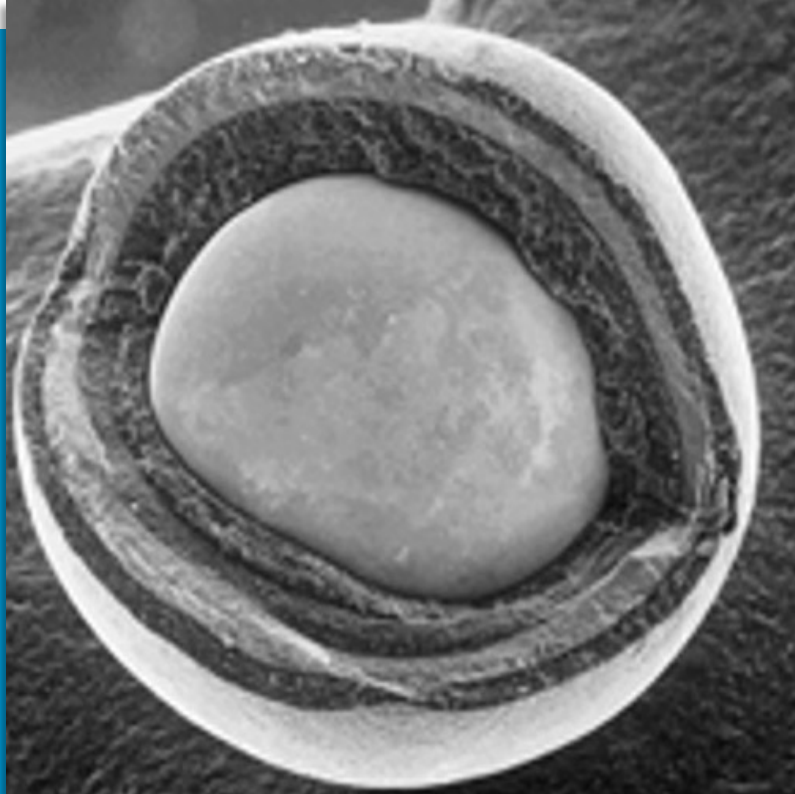


Kairos Power Team

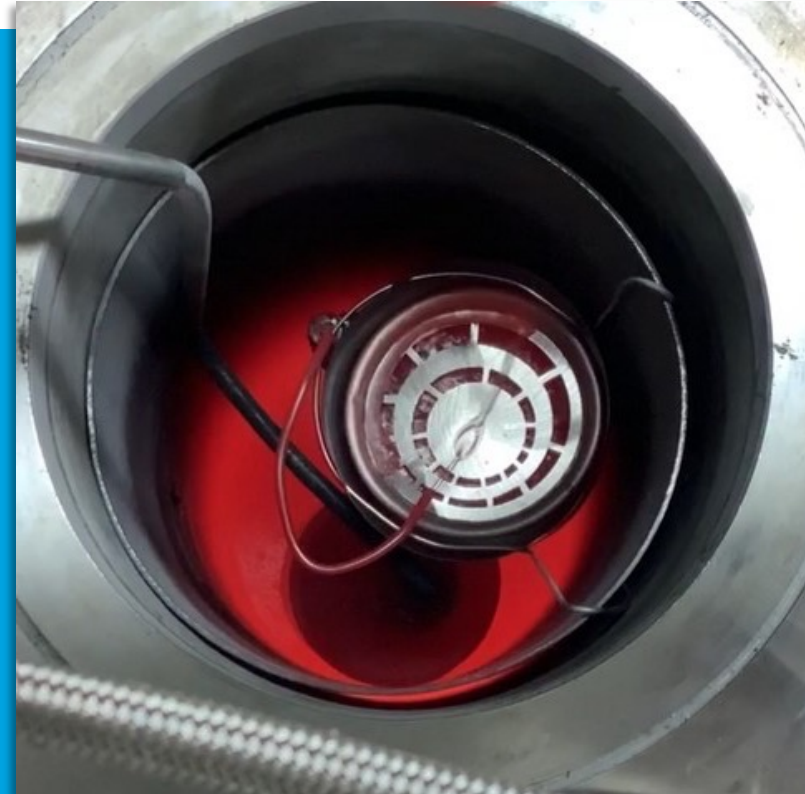


Fluoride Salt-Cooled High Temperature Reactor

Technology Basis



Coated Particle Fuel
TRISO



Liquid Fluoride Salt Coolant
Flibe ($2\text{LiF}-\text{BeF}_2$)

Kairos Power Workstreams

Reduce risk and build cost certainty

KP-X Design

Test Program

Licensing

Fuel Development

Salt Development



Technology
Certainty

Licensing
Certainty

Supply Chain /
Manufacturing Certainty

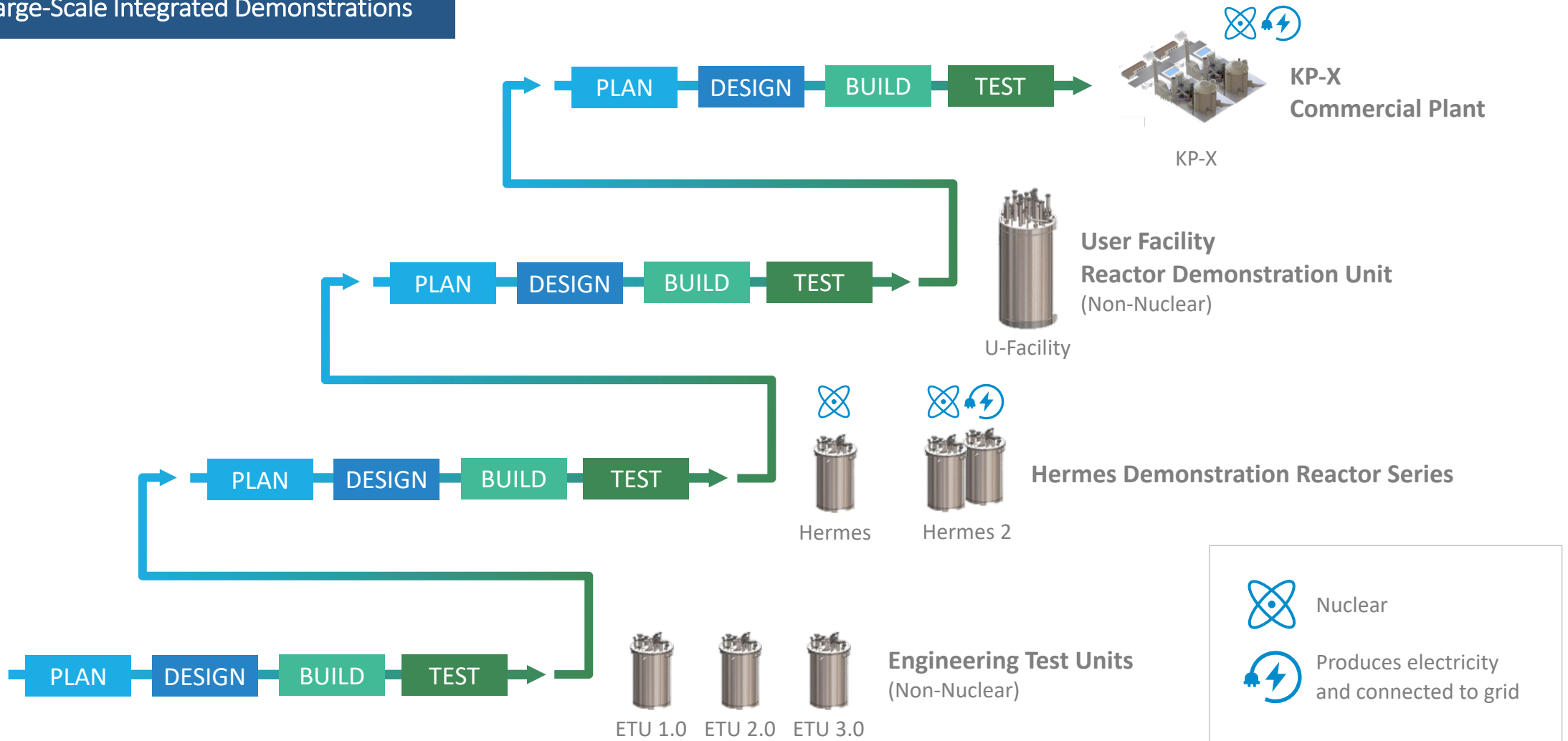
Build
Certainty



Cost
Certainty

Kairos Power Path to Commercialization

Successive Large-Scale Integrated Demonstrations



Kairos Power Locations and Infrastructure



HQ / R-Lab / S-Lab
Alameda, CA



T-Facility / Engineering Test Unit
Production Development Facility
Albuquerque, NM



Molten Salt Purification Plant
Elmore, OH

Instrumentation Labs
Rexford, NY

Hermes Reactor
Oak Ridge, TN

Licensing Office
Charlotte, NC



Kairos Power Facilities

- RAPID Lab
- Salt Lab
- Testing Facility

Flibe & Fuel Production

Vertical Integration

Molten Salt Purification Plant
Elmore, OH



First batch of Flibe arrives at KP Southwest
April 2023



TRISO Development Lab
Albuquerque, NM



Pebble Development Lab
Albuquerque, NM



Supply Chain Development

Procurement of 316H

- **316H Reactor System Components**
 - 316H is produced in accordance with ASME Sect III Div 5 Subsection HAA-1110 and HBB Table U-1
 - Hitting the composition specification requires a heat lot that ranges from 80 – 150 MT of product
 - Many mills can produce 316SS, but hitting all chemistry ranges for 316H is challenging, and many mills are not ASME certified
 - Even early iterative test programs using ‘standard’ 316H are challenging because the material does not generally exist commercially “off-the-shelf” except for only the most common product forms

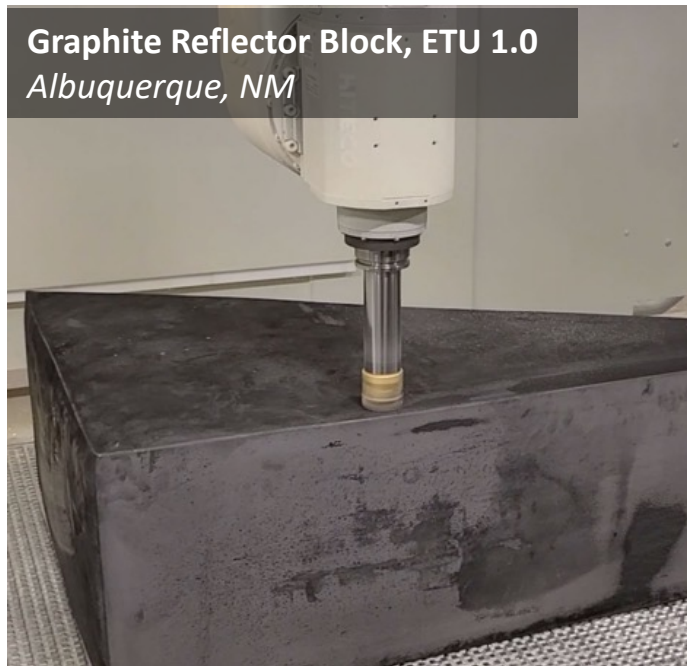


316H ingots

Graphite Machining

Vertical Integration

- **Graphite Reflector Machining Capabilities for ETU 1.0**
 - ET-10 graphite supply for the reflector system is sourced from Japan
 - The machining process that converts the graphite billet into reflector blocks is ~ 2/3 of the value chain
 - Since reflector block placement requires precision machining that can be iterative, it made sense to vertically integrate this capability
 - Kairos' initial goal: produce 25% of the blocks for ETU 1.0
 - Reality: we machined > 50% of the reflector blocks and plan for 100% of graphite machining for ETU 2.0

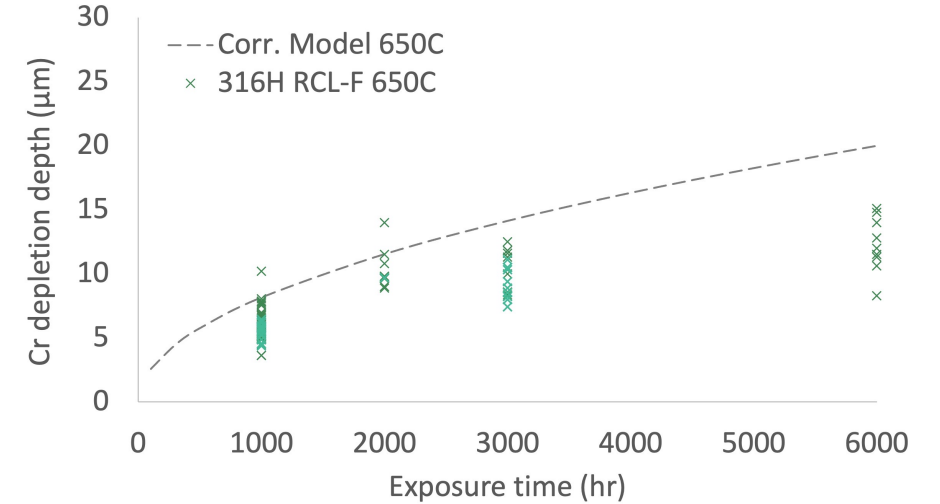
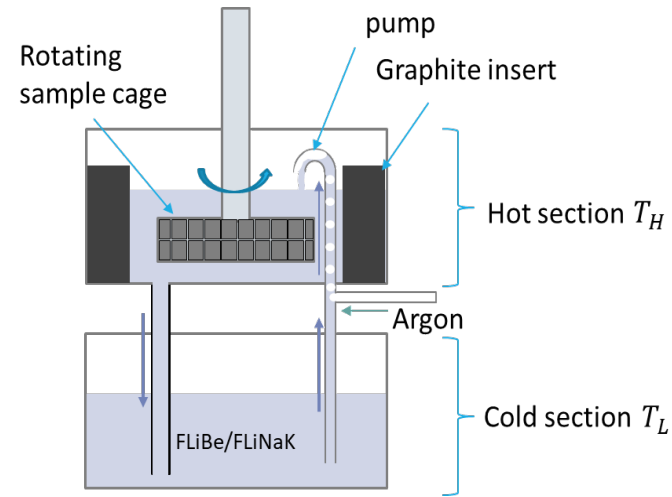
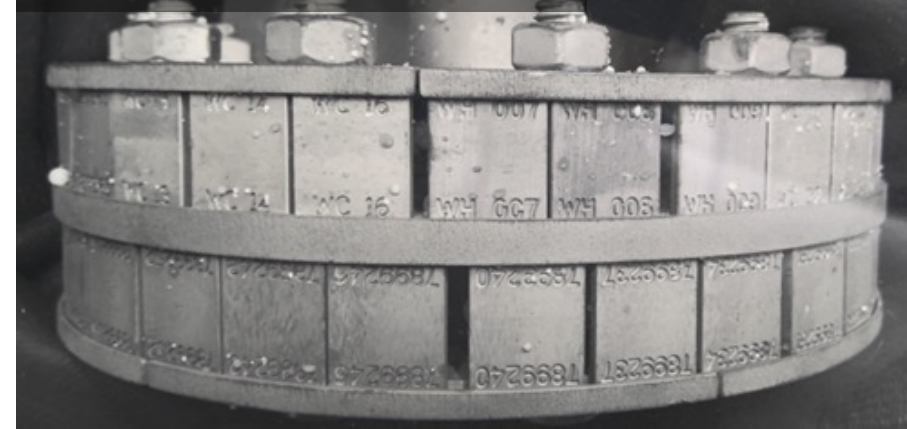


Materials Testing and Technology Development

Corrosion Behavior

- A proprietary system was designed and built to understand corrosion under prototypical reactor flow, temperatures, with cold leg
- Accumulated > 12,000 hours of continuous corrosion testing to obtain long-term trends on corrosion in FLiBe at different temperatures
- Results show that when electrochemical potential of the salt is controlled, Cr depletion is solid-state diffusion limited and corrosion rates are relatively low

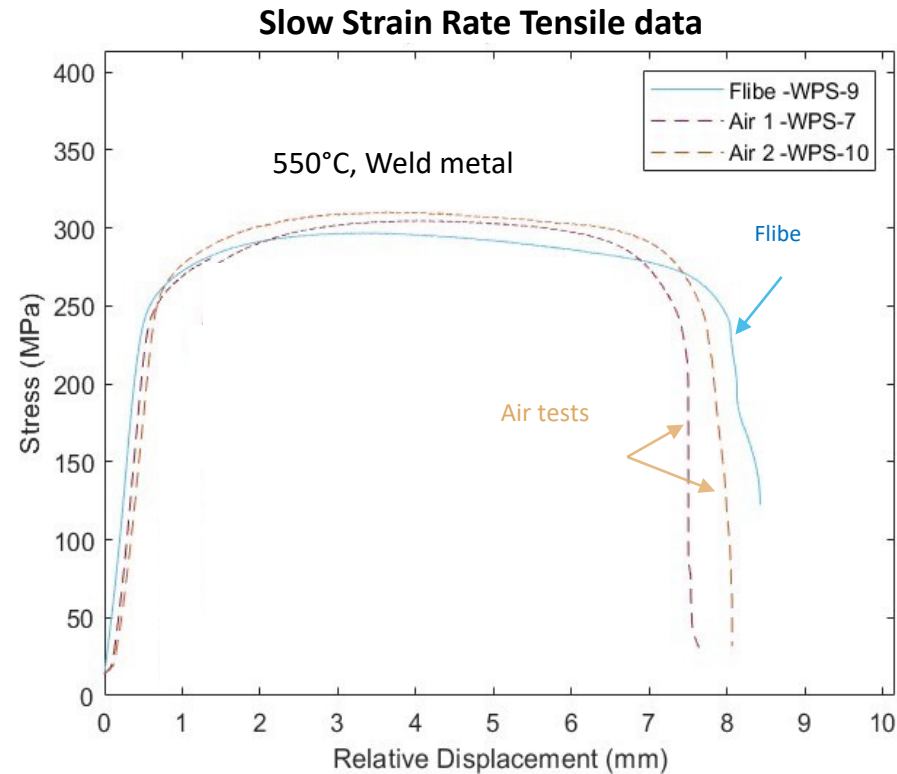
Sample Tree in Rotating Cage
Loop for Corrosion Testing
Alameda, CA



Materials Testing and Technology Development

Mechanical Behavior

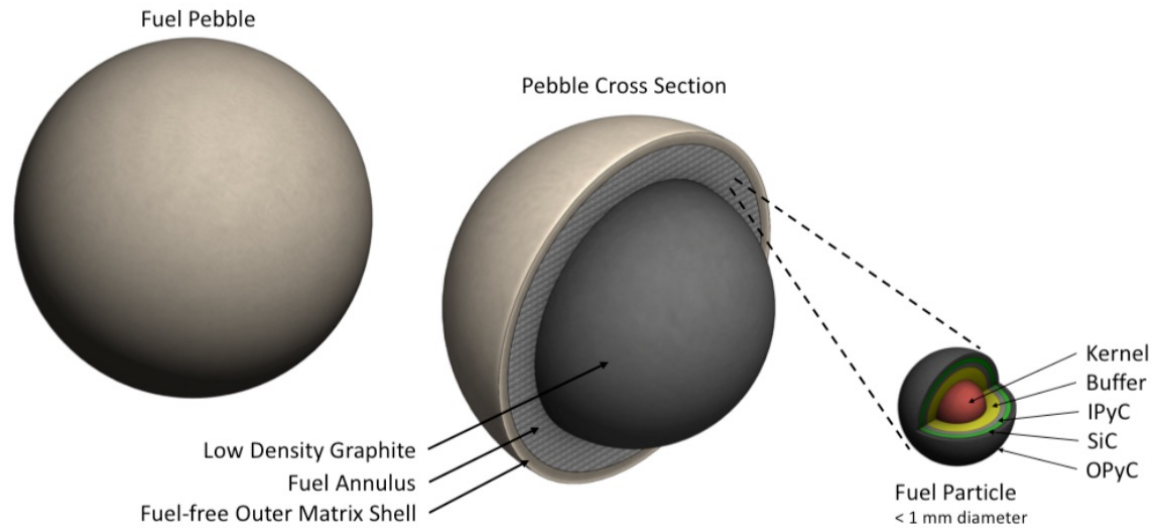
- A proprietary system was designed and built to quantify mechanical behavior of 316H in molten Flibe up to 750°C
- 35+ tests of 316H stainless steel, cross-weld, and all-weld specimens
- Results show no difference in mechanical behavior between air and Flibe within specifications
- Designed self-loaded miniature compact tension specimen for future in-situ **Flibe + irradiation** testing at MIT



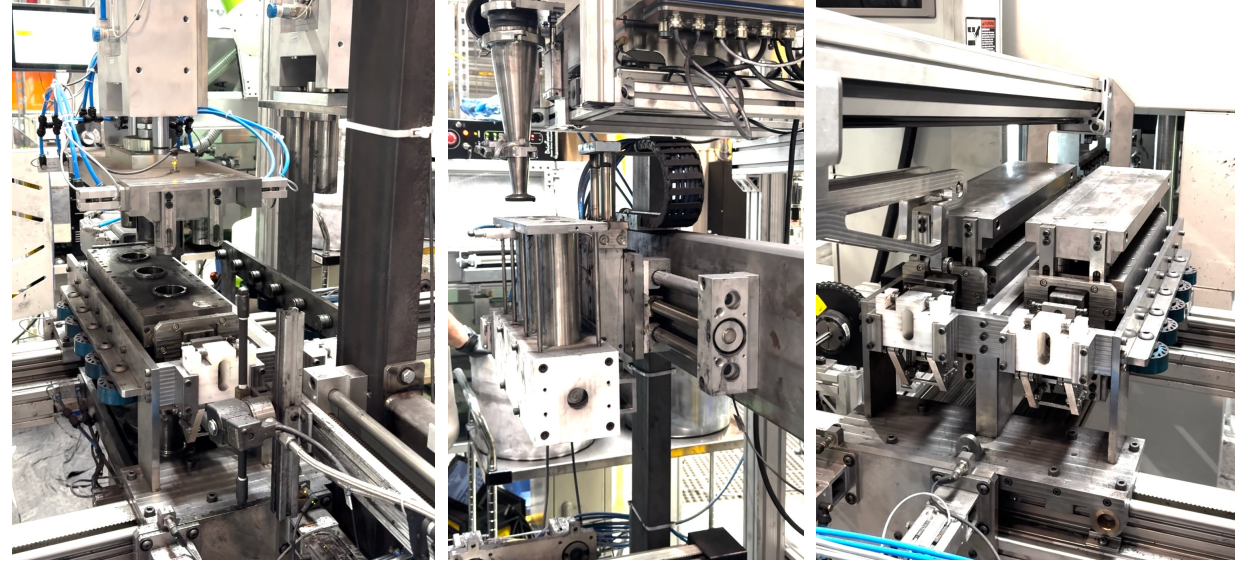
Annular Fuel Pebble Fabrication Development

Vertical Integration

- **Annular Fuel Pebble Fabrication**
 - Development of fabrication methods and process equipment to manufacture the annular fuel pebble has required many iterations
 - The focus is now on automating fabrication processes to improve quality and accelerate manufacturing

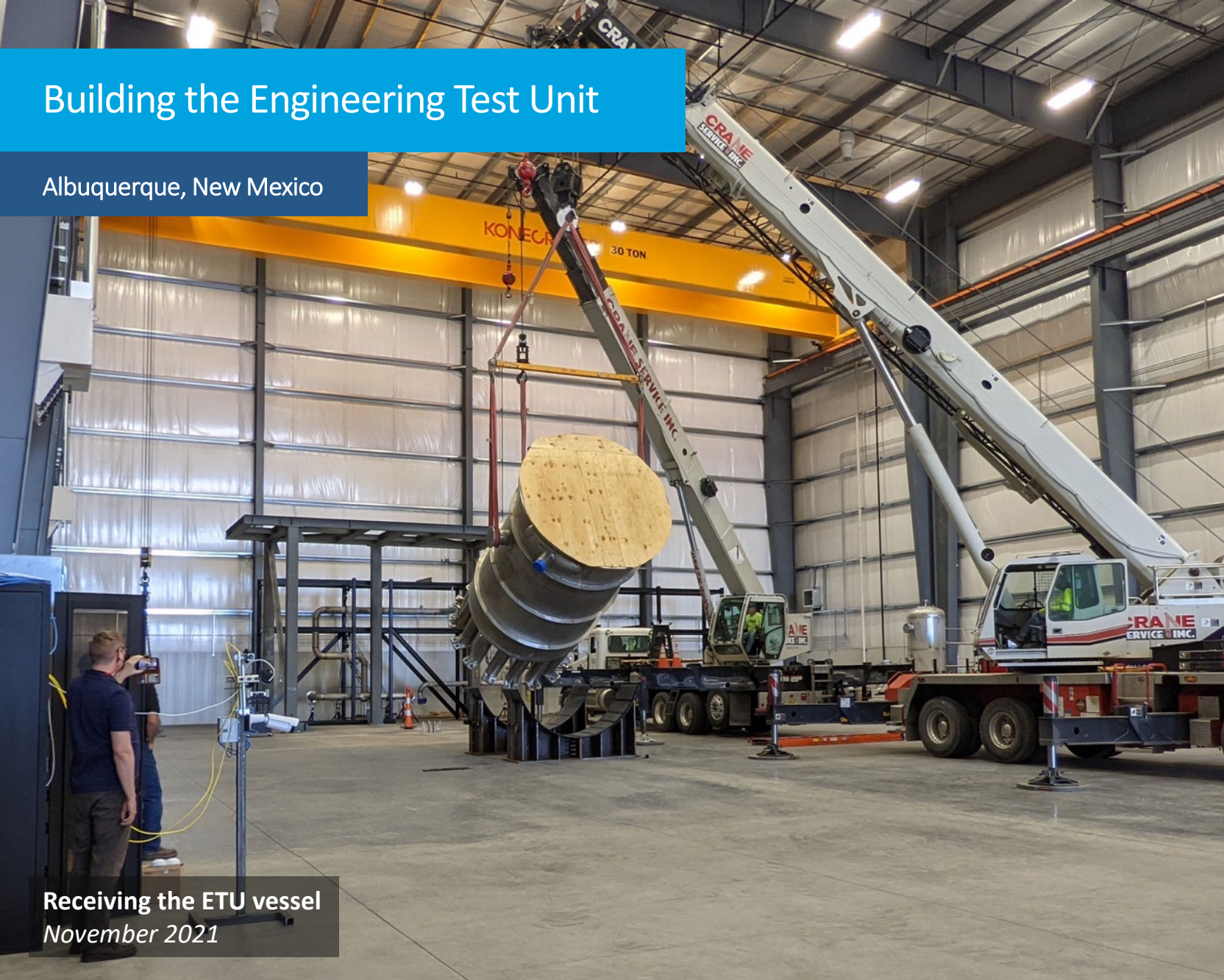


Automated Pebble Manufacturing System for Annular Fuel Pebbles
Albuquerque, NM

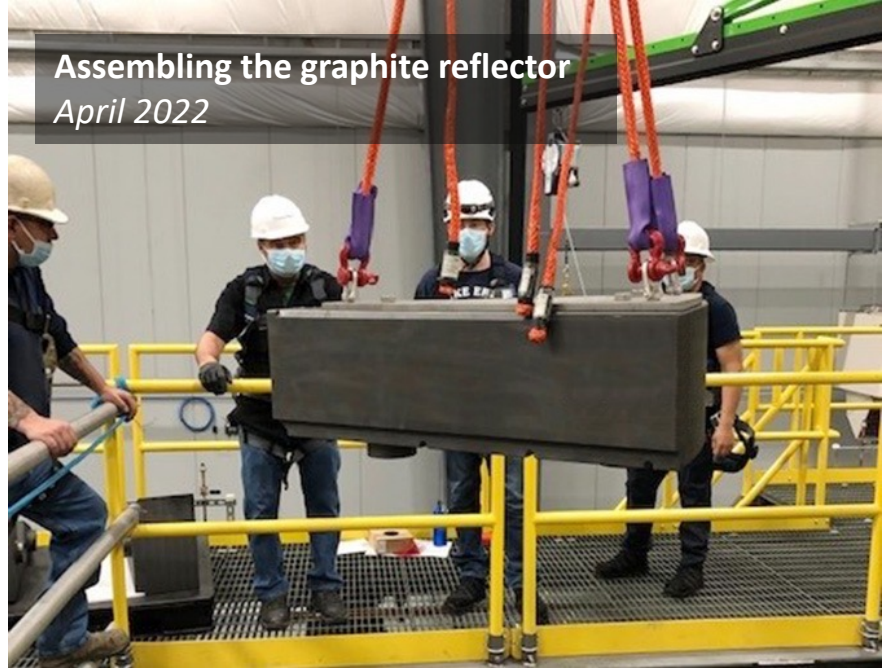


Building the Engineering Test Unit

Albuquerque, New Mexico



Receiving the ETU vessel
November 2021



Assembling the graphite reflector
April 2022



Adding the 30,000th simulated fuel pebble
May 2022

Engineering Test Unit

Albuquerque, NM



ETU construction complete
June 2023

Flibe arrives at KP Southwest
August 2023



KP Southwest
Control Room



Argos Remote
Control Room



ETU 1.0 Testing Progress

2,000+ Hours of Pumped Salt Operations

- **ETU 1.0 testing highlights at 550+°C:**
 - Loaded 12 metric tons of molten salt into the largest Flibe system ever built
 - Demonstrated online refueling with surrogate fuel via the Pebble Handling and Storage System
 - Achieved highest-ever Flibe flow rate up to 3,000 GPM
 - Logged over 25,000 strokes of the Reactivity Control System
 - Commissioned a first-of-its-kind chemistry control system to continuously monitor purity of Flibe in the system



Lessons learned from the ETU program will inform the design and operation of the Hermes demonstration reactor in Tennessee

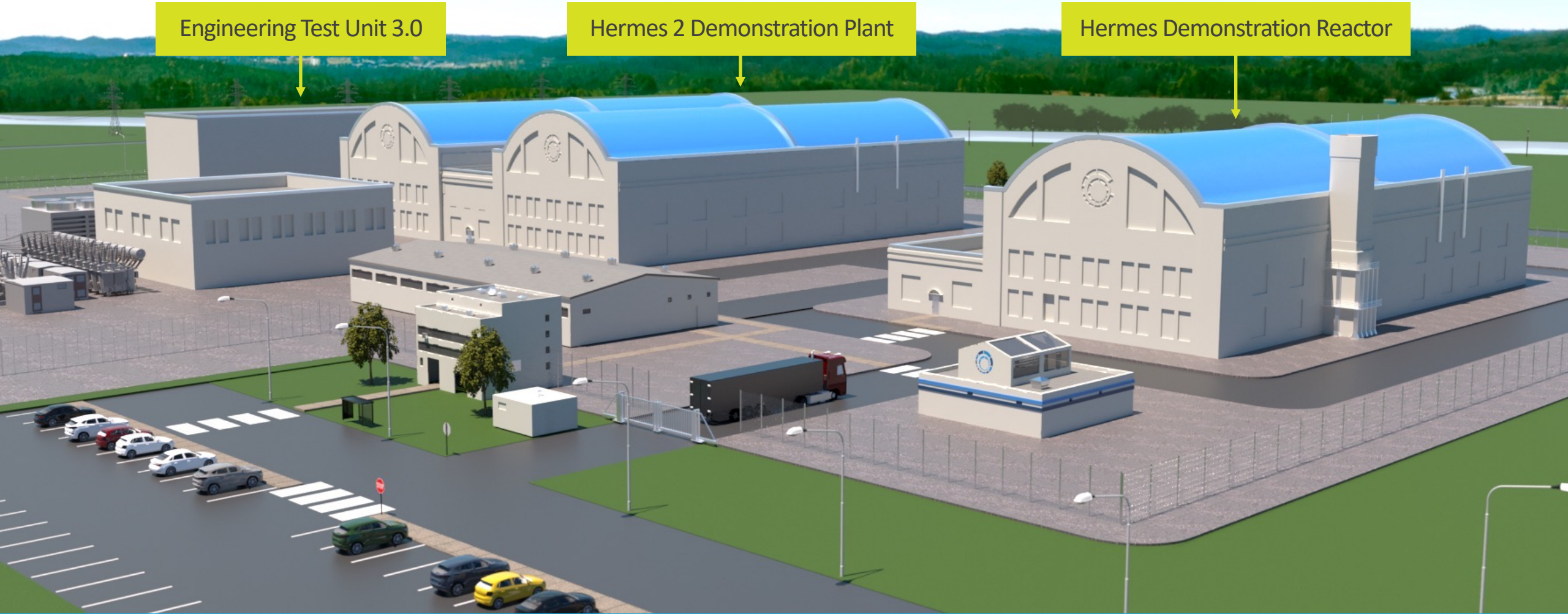
Hermes Demonstration Reactor Series

Heritage Center K-33 Site / Oak Ridge, TN

Engineering Test Unit 3.0

Hermes 2 Demonstration Plant

Hermes Demonstration Reactor



Hermes Demonstration Reactor Series

Leading the Way in Advanced Reactor Licensing

- The U.S. Nuclear Regulatory Commission issued a construction permit for the **Hermes demonstration reactor** in 2023 following an accelerated application review enabled by robust pre-application engagement
- Kairos Power submitted a construction permit application (CPA) for the **Hermes 2 demonstration plant** in July 2023, which builds upon the successful Hermes CPA
- **Major licensing accomplishments to date:**
 - ✓ **12 of 12 topical reports supporting KP-FHR licensing approved**
 - ✓ **Hermes Construction Permit Issued by NRC in Dec. 2023**
 - ✓ **First CP for a non-water-cooled reactor in over 50 years**
 - ✓ **Hermes 2 CPA accepted for review in Sept. 2023**



Kairos Power completed its mandatory hearing for the Hermes CPA and received its construction permit in Q4 2023

KP-OMADA Advanced Nuclear Alliance

The Kairos Power Operations, Manufacturing and Development Alliance brings together leading North American utilities and generating companies to collaborate on the advancement of KP-FHR technology.

BrucePower

 **Constellation**

 **Kairos Power**

 **Southern Company**

TVA **TENNESSEE
VALLEY
AUTHORITY**





Kairos Power

Enabling the world's transition to clean energy
while improving people's quality of life
and protecting the environment

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