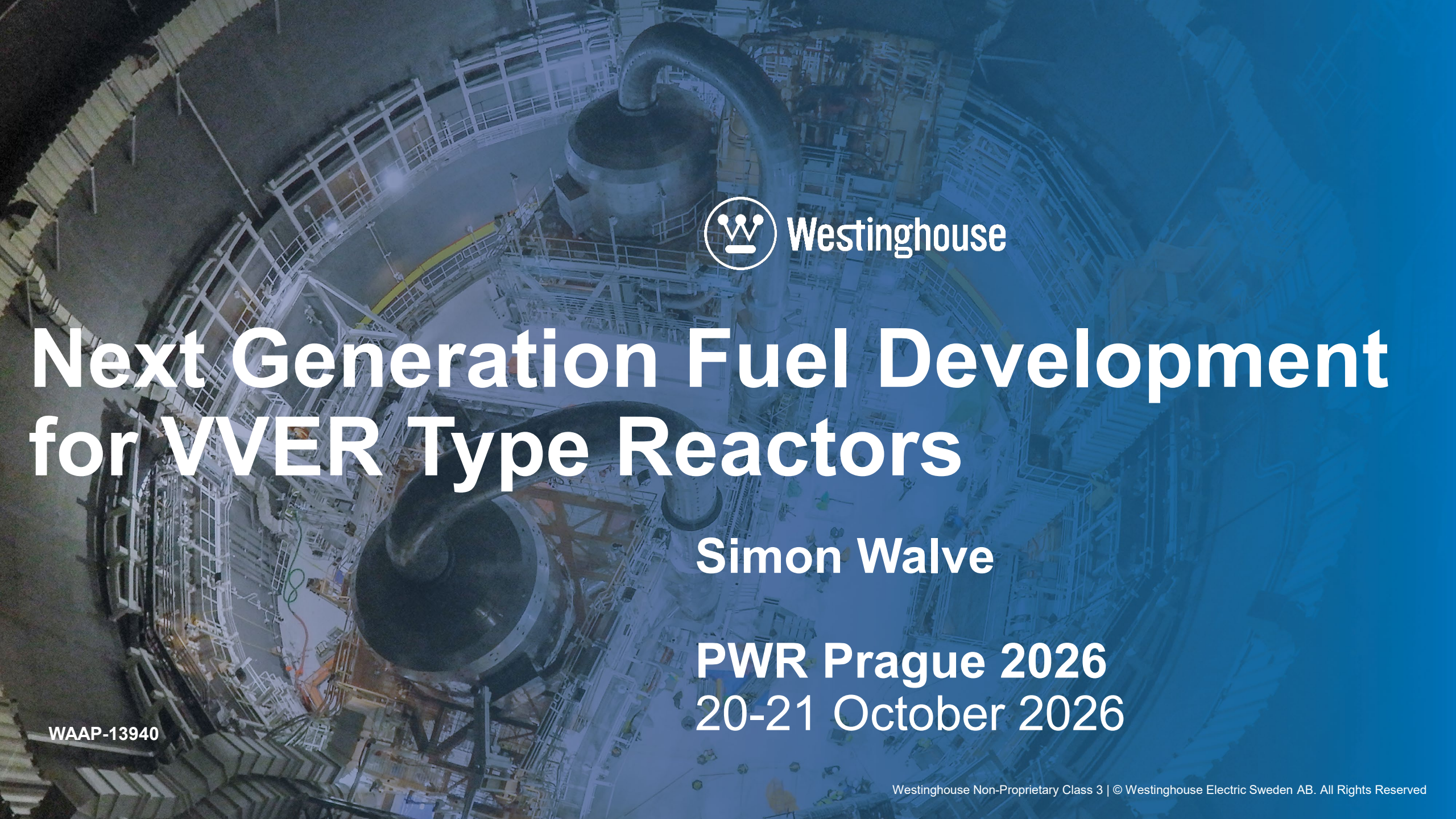


Next Generation Fuel Development for VVER Type Reactors

Simon Walve

PWR Prague 2026
20-21 October 2026

WAAP-13940

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Why continue developing VVER fuel?



Common objective

Improved fuel economy, reliability and manufacturability

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Established VVER Fuel Platforms





VVER-1000

RWFA and RWFA-T

- Operating experience in mixed and homogeneous cores
- Ukraine, Czech Republic and Bulgaria
- Currently no leakers in cores

VVER-440

NOVA E-5 / E-6 fixed fuel design
NOVCC / NOVCD follower fuel design

- Operating experience in mixed cores
- Ukraine and Finland
- Currently no leakers in these fuel types

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Two Development Paths, Common Objectives

VVER-1000

Next-generation structural grid

- Neutronic, mechanical and thermal-hydraulic performance
- Cell-based grid architecture to gain strength
- Reduced hydraulic resistance

VVER-440

NOVA E-7 fuel assembly concept

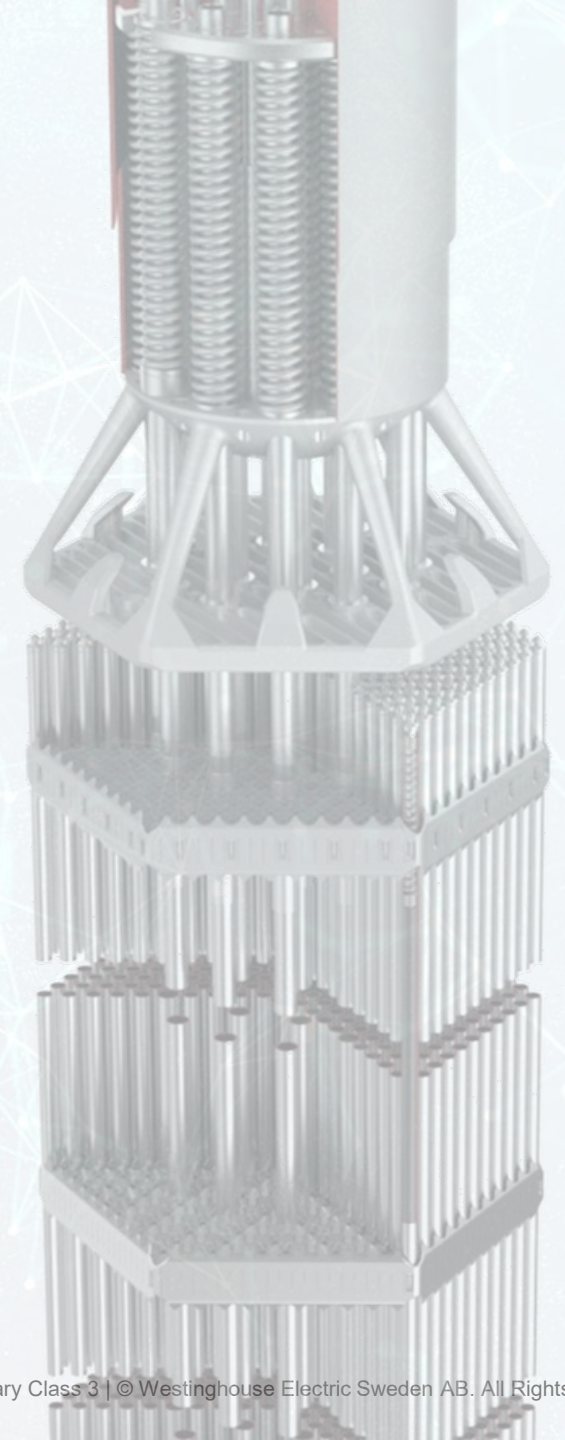
- Improved neutron economy
- Increased water-to-uranium ratio
- Optimized geometry and components

Fuel economy • Reliability • Manufacturability

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VVER-1000 fuel



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Westinghouse VVER-1000 FA Designs

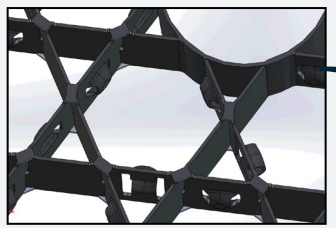
18 Guide Thimble +
1 Central Tubes

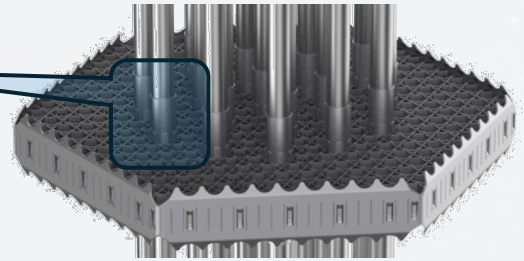
Top Nozzle

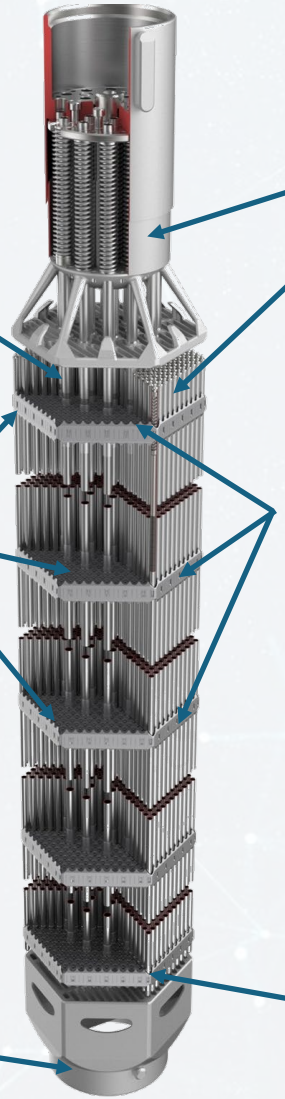
312 Fuel Rods

RWFA – Mid Grids w/o Mixing Vanes

- 15/12 A718/Zr1%Nb Top/Mid Grids







RWFA – Mid Grids with Mixing Vanes

- 12 A718/Zr1%Nb Top/Mid Grids
- 5 Mid Grids with mixing vanes

Bottom Nozzle

Bottom A718 Grid

Grids are made of intersecting straps with co-planar springs and dimples

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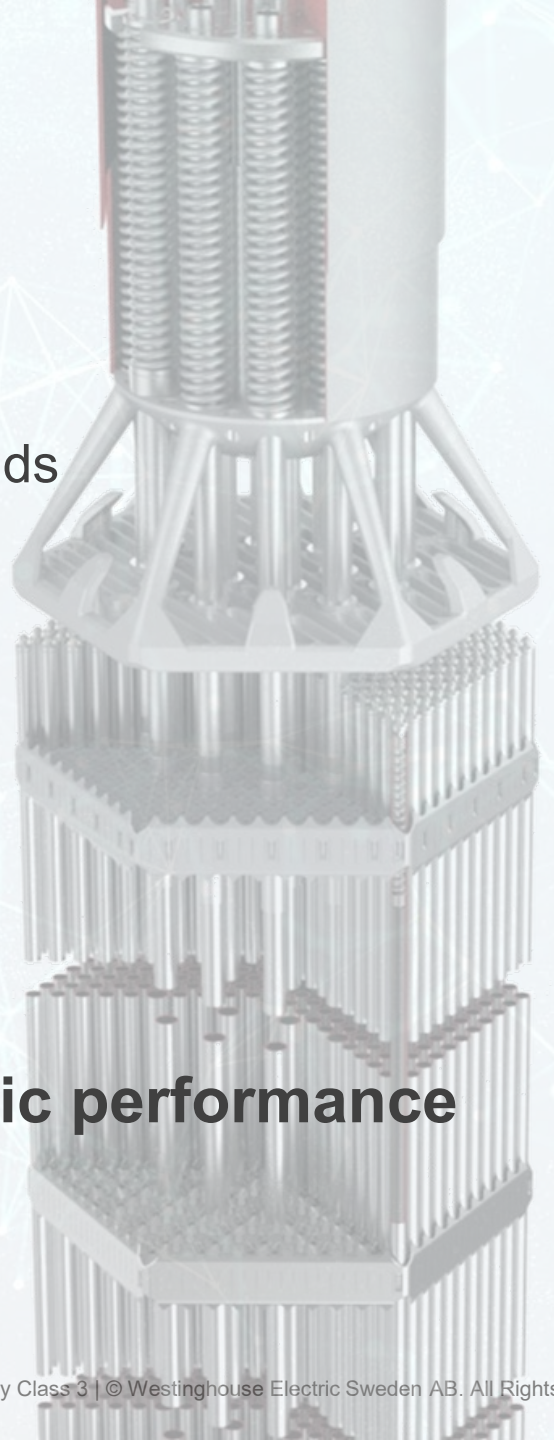
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VVER-1000: Design objectives

Key objectives: Enhance fuel economy and fuel reliability

- Mid grids of **Zr-alloy material** to replace current RWFA A718 mid grids
- Enhance Zr-grid **lateral strength** to match RWFA A718 grids
- Reduce **pressure drop**
- Maintain or improve **GTRF margins**
- Option: Mixing grid for DNB margin enhancement
- Option: Enhanced debris filtration (not started)

Balance neutronic benefit, lateral strength and hydraulic performance

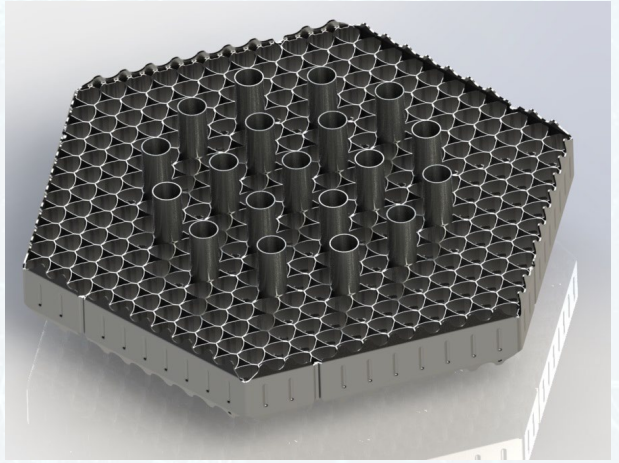


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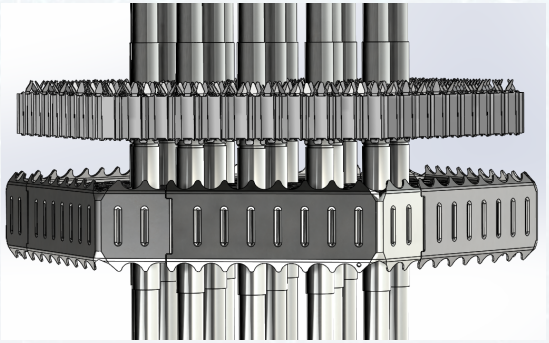
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Next Generation Grid Design Overview

- Conventionally Manufactured Low Tin ZIRLO™ (LTZ) structural grids
  - Novel cell-based grid design
  - Increased height and material thickness to match RWFA A718 grid strength, balancing with pressure drop



- IFM mixing grid
  - Based on the existing vaned grid design for Temelín NPP



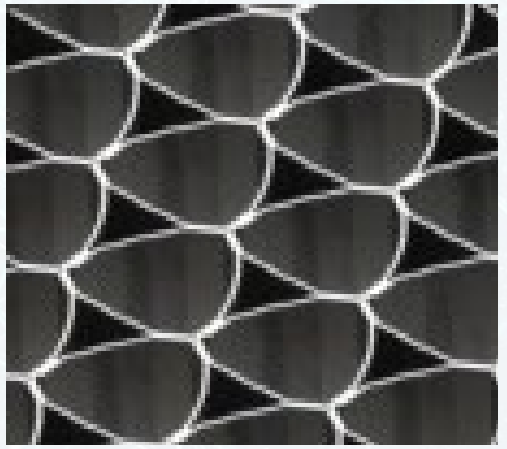
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Individual Grid Cells

- Individual cells are used for fuel rod positioning and support
  - Cells are formed from coiled sheets which are
    - Cut
    - Stamped
    - Bent to desired shape

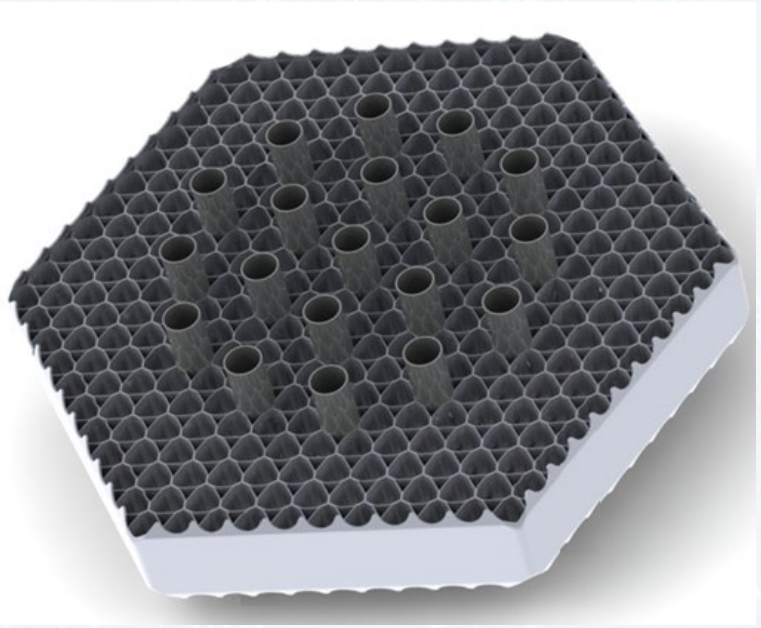




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Individual Cell Based Grid Design

- Individual cells, outer straps and sleeves are assembled in welding fixture and joined by laser welding
  - Similar process used for making BWR grids at WSE factory
  - Grids may be heat treated with use of mandrels to set a design cell size with tight tolerances
  - Extensive experience concerning dimensional tolerances and process capability
  - Minimized quantity of unique cell types for improved manufacturability

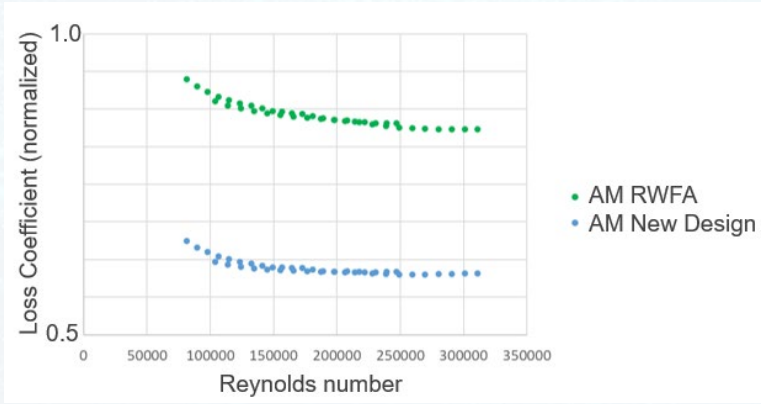


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Early Scoping Tests with Additively Manufactured Prototype Grids

- Full-size prototype test grids built in A718 material by AM
  - New cell-based NG grid concept and RWFA design as reference
- Pressure drop test in EMBLA Loop
  - NG concept showed **30% lower grid pressure drop** compared to RWFA for same material thickness and grid height
- Lateral Load Test
  - NG concept showed similar load capacity vs. RWFA
  - **Potential to increase grid strength** (when changing material to Zr) by increasing thickness and height, thereby sacrificing some of the pressure drop reduction



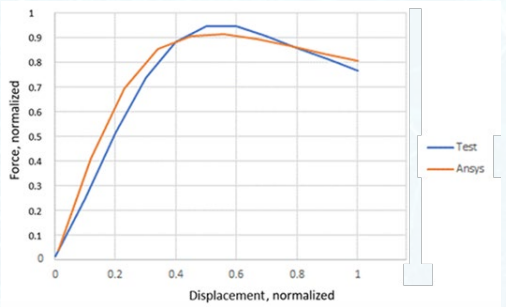


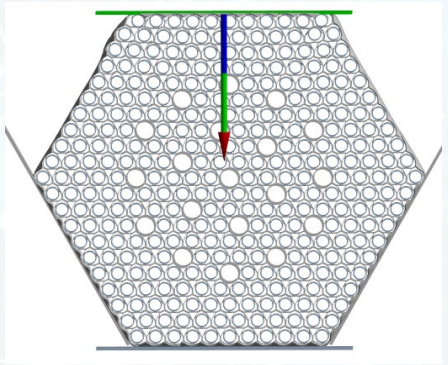
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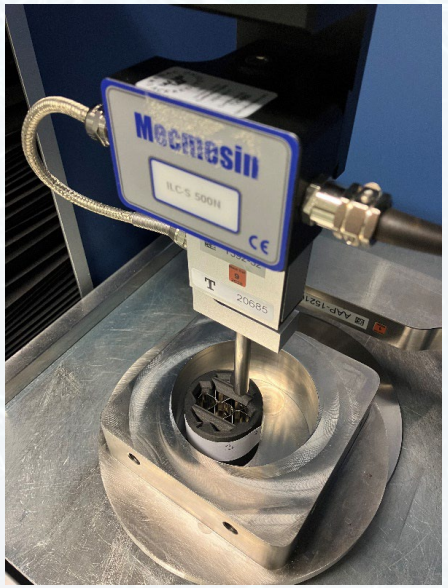
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Scoping Tests and Simulations

- Two spring designs were selected for the detailed grid design and manufacturing development
- Load deflection testing of springs stamped on flat sheets
  - Served to validate ANSYS structural analysis models, allowing further optimization of spring properties
- Manufacturing of LTZ mini-grids
  - Test samples of 7-cell grids (both spring designs)
- Mini-grid cell stiffness testing
  - Both spring designs demonstrated as predicted in-cell load-deflection characteristics
- Fuel rod loading test in mini-grids
  - Drag force during fuel rod insertion was as expected and acceptable for both spring designs
- Conclusions from structural simulations with full-grid models
  - Grids with both spring designs show potential to meet requirement of same strength as RWFA A718





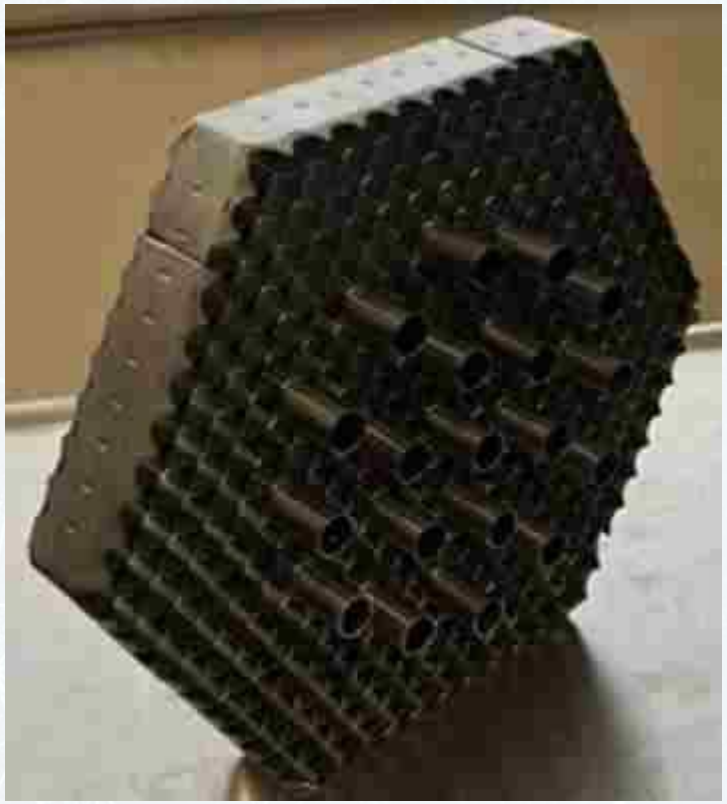


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Final Grid Design and Manufacturing Achievements

- Optimized quantity of components for grid assembly manufacturing
  - Order of magnitude reduction in grid components/stamping dies
  - Clever component arrangement for grid assembling and welding
- Stamping
  - High-quality prototype cells and frame sections produced, meeting engineering tolerances
  - Manufacturability of the complex hexagonal frame corner successfully demonstrated
  - No manufacturing showstoppers identified
- Welding
  - Welding fixtures optimized to improve assembly efficiency while maintaining accuracy
  - Weld quality and dimensional stability validation ongoing
  - Prototype grid assembly successfully welded



Manufacturability demonstrated with successful prototype production and assembly; qualification activities continue.

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Steps going Forward

- Manufacturing of test grids for final scoping and verification testing
- Final scoping tests of grid crush strength and pressure drop (including IFMs)
- Verification of GTRF performance (VIPER Loop)
- Lead Test Assemblies (LTAs)

Manufacturing of first batch of full-size test grids ongoing

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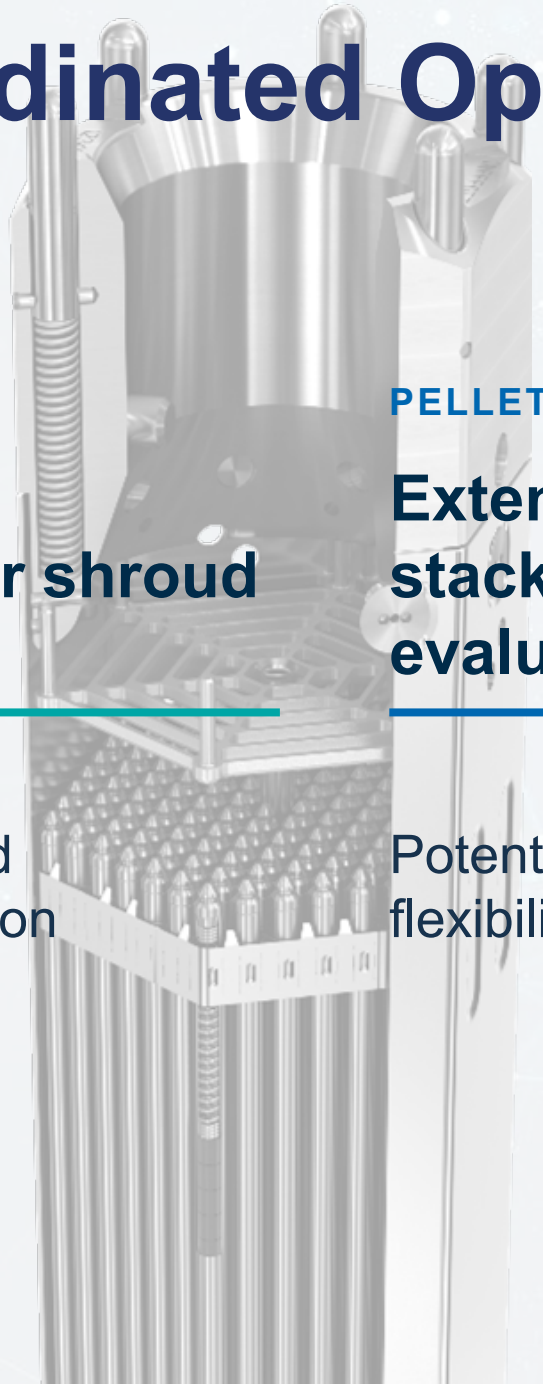
VVER-440 fuel



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VVER-440: Coordinated Optimization of Fuel



ROD LATTICE

Increased fuel rod pitch

Higher water-to-uranium ratio

SHROUD

Thinner shroud

Improved moderation

PELLET STACK

Extended pellet stack under evaluation

Potential added flexibility

COMPONENTS

Optimized components

Material use and manufacturability

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Customer Feedback Informs Priorities

- Fuel economy and operating margins
- Handling and structural robustness
- Compatibility with methods and plant interfaces
- Need for analysis, testing and irradiation validation

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Conceptual NOVA E-7 Fuel

ROD LATTICE

Evolutional strap-based grid design

SHROUD

Shroud robustness and manufacturability with thinner material
Maintain inspection capability

PELLET STACK

Potential to be increased both in bottom and top end

COMPONENTS

Improved to enable above features and reduce material use



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Summary

VVER-1000	Next-generation grid development targets improved neutron economy and lower hydraulic resistance while maintaining mechanical and thermal-hydraulic performance.
VVER-440	NOVA E-7 fuel coordinates fuel lattice, shroud and component optimization to improve fuel economy, robustness and manufacturability.

Proven platforms provide the foundation. Targeted innovation, verified step by step, delivers the next gains in fuel economy, reliability and manufacturability.

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Thank you for your attention

Questions?

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