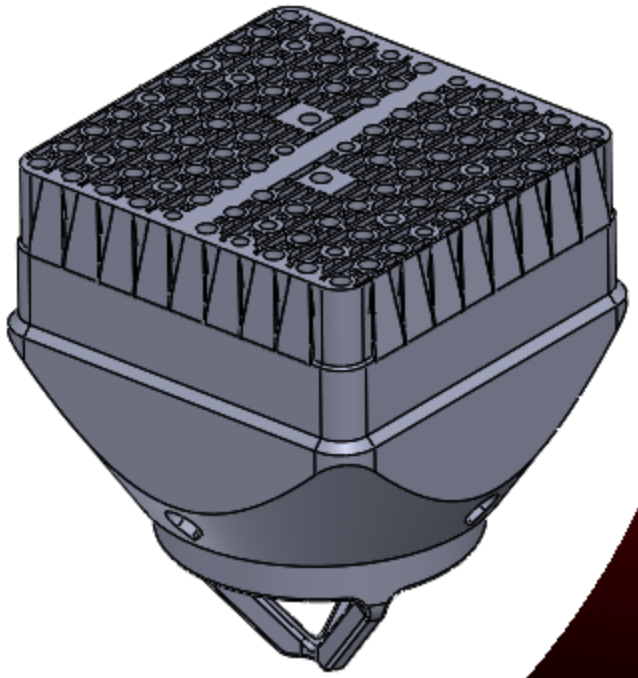
ADDITIVE MANUFACTURING OF BWR LOWER TIE PLATES



AMM Technical Review Meeting Webinar
December 17-18, 2019

Presented By:
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Funded By:
DOE SBIR Phase II Grant, DE-SC0018799

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Acknowledgement and Disclaimer

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Agenda

- NovaTech Overview
- Project Team
- Objectives
- Project Plan
- Project Status
- Publications
- Future Tasks
- Q&A

Who is NovaTech?

- Founded in 1994
- Located in Lynchburg, VA
- Quality Assurance Program Compliant with:
  - ASME NQA-1
  - 10CFR50 Appendix B
- Business Segments
  - Aerospace
  - Defense
  - **Nuclear**
  - Industrial

Project Team

- Lauren Gramlich – Principal Investigator (PI)
- Anne Austin – Engineering Manager
- George Pabis – Principal Engineer
- Lew Walton – Consulting Engineer

Project Objectives

- Additively manufacture (AM) a monolithic Boiling Water Reactor (BWR) Lower Tie Plate that will be ready for implementation on lead assemblies at the conclusion of Phase II.
  - Reduce part count by combining parts
    - Nose piece
    - Tie plate with debris filter
    - Channel seals
  - Improve performance
    - Debris capture
    - Pressure drop
  - Utilize geometries that were previously not manufacturable
    - Torturous path

Project Plan

- Lower Tie Plate Design
  - Improve Phase I designs
  - Consult with utilities and fuel suppliers
- Lower Tie Plate Analysis
  - FEA
    - Shipping
    - Handling
    - Normal Operation
    - Accident Conditions
  - CFD
- Other FA Components
  - Research, design, analyze

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Project Plan

- Production
- Bench Testing
  - Dimensional Inspection
  - Flow Test
    - Pressure Drop
    - Debris Capture
- Full-Scale Testing
  - Assembly Fit-Up
  - 1000 hour life and wear test

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Design Basis

- Design basis is a GE14 fuel assembly
  - 10x10 array
  - 92 fuel rods
    - includes 8 tie rods, 14 partial length rods
  - 2 water rods

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Concepts

Concept A

- Torturous path
  - Single hump design
- Bypass Hole
  - Teardrop
- Channel seal springs
  - Flat cantilever

Concepts B & C

- Torturous path
  - Double hump design
- Bypass Hole
  - Torturous path
- Channel seal springs
  - Curved cantilever

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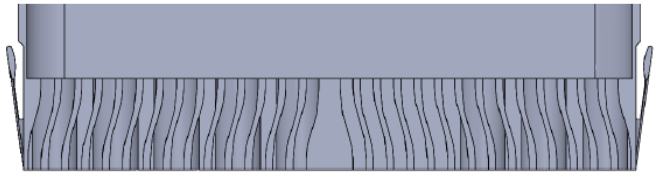
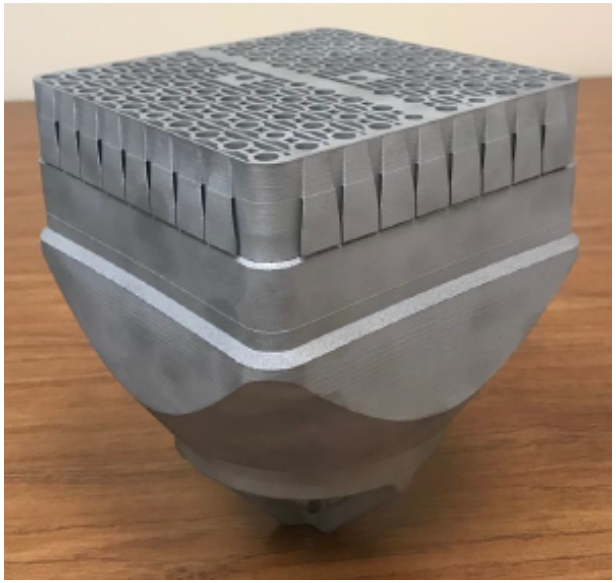
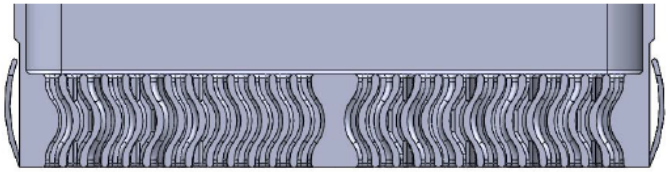
Concepts

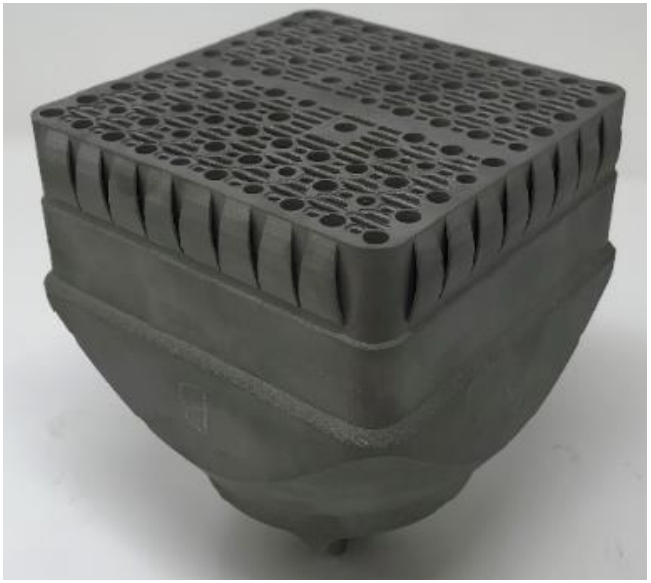
Concept A



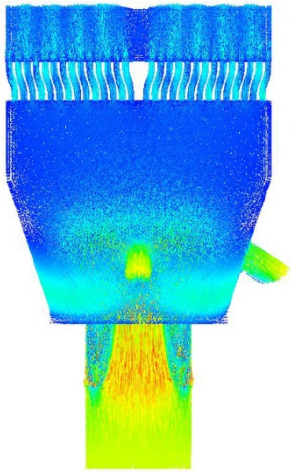
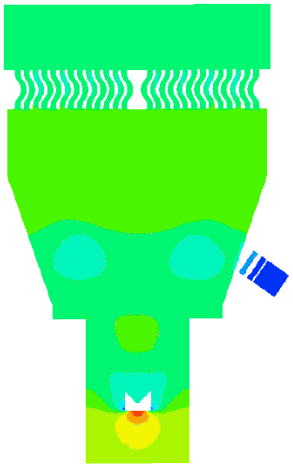
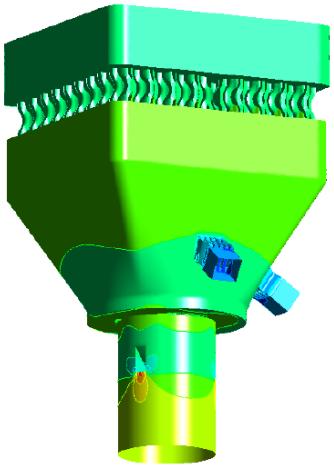
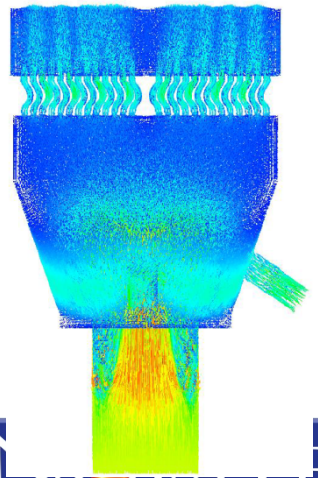


Concepts B & C



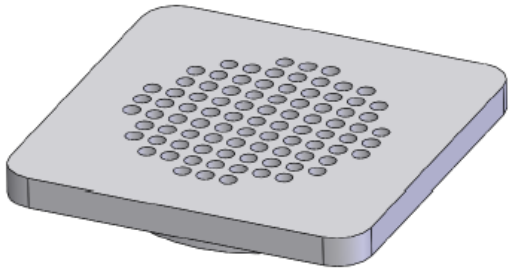


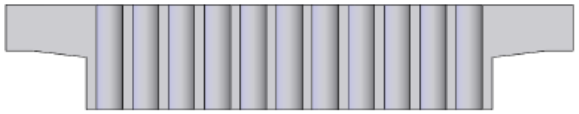
CFD Analysis

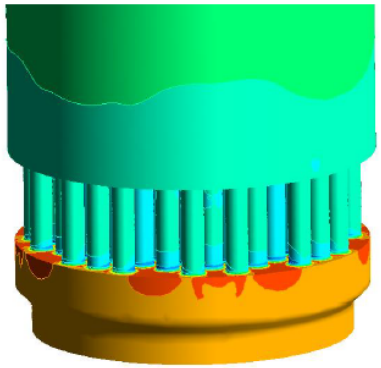
	Pressure Center Cross-Section	Pressure Isometric	Velocity Vectors Center Cross-Section
Concept A			
Concepts B & C			

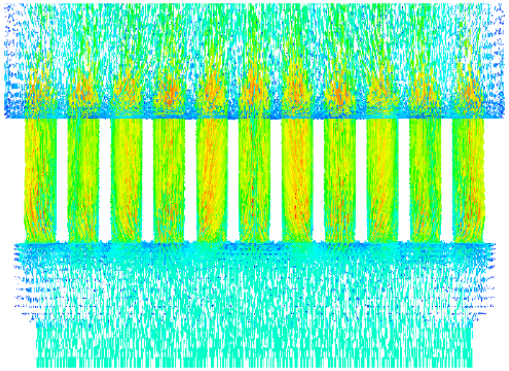
Test Standard

- Flow test baseline

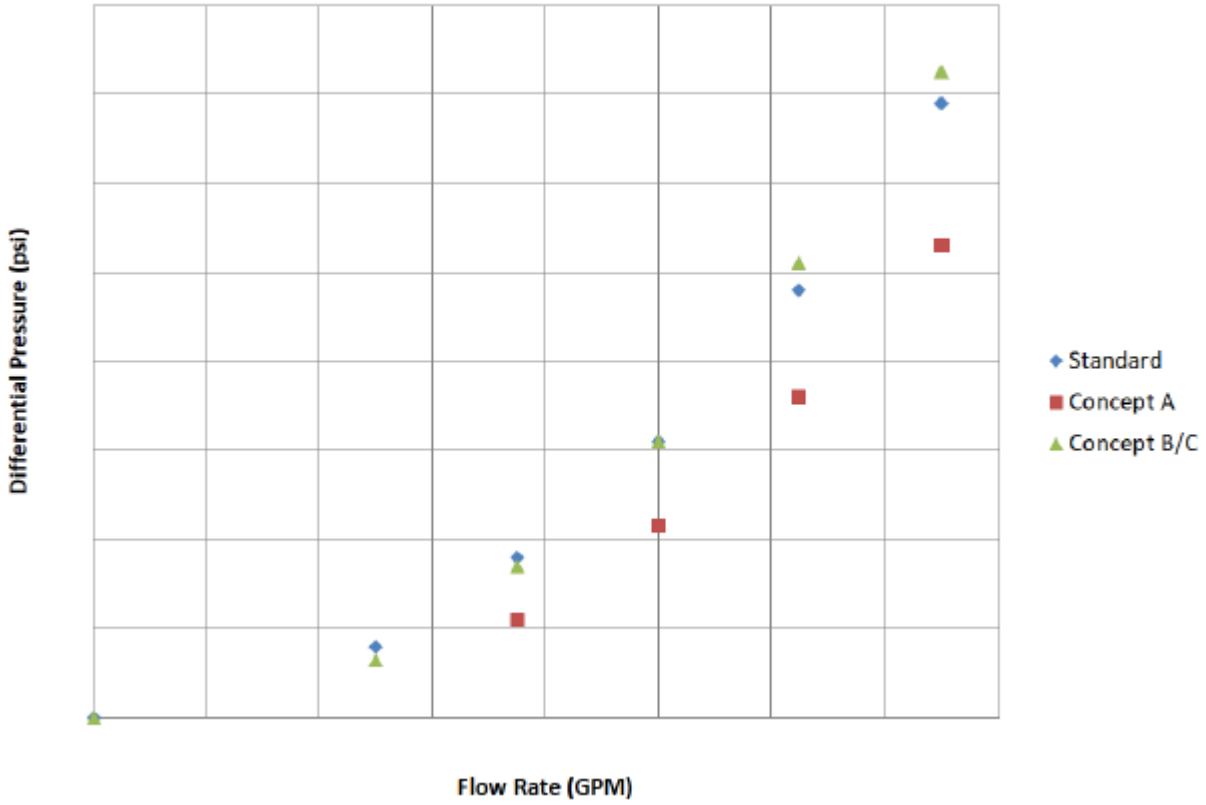






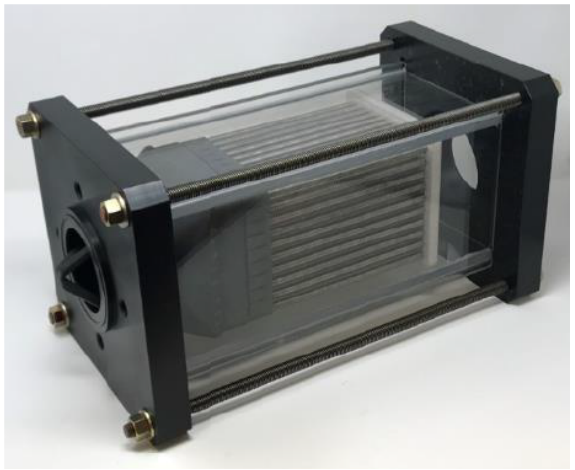


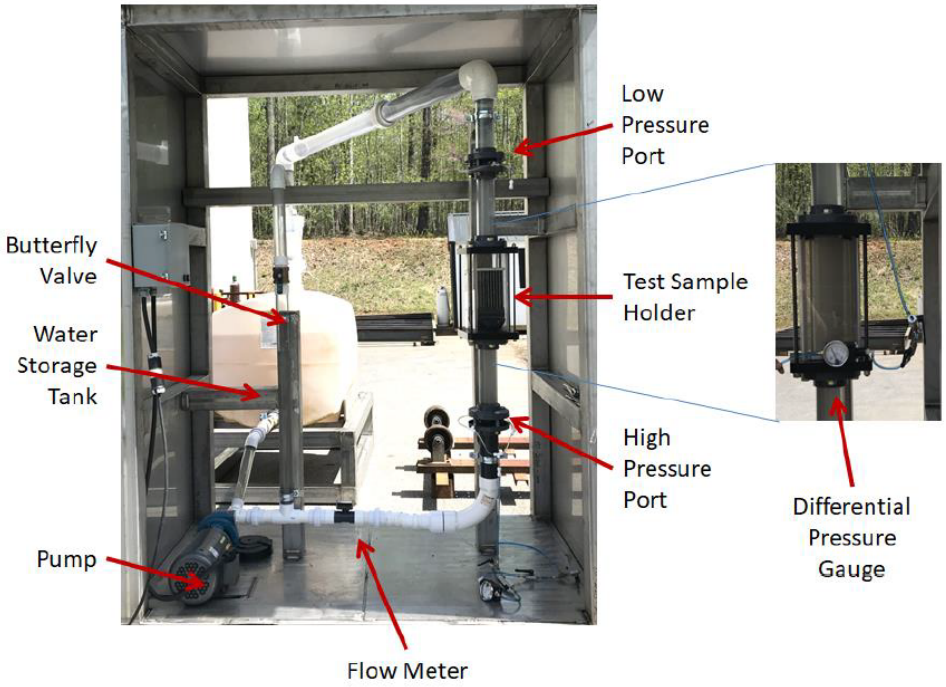
CFD Results


Differential Pressure (psi)
Flow Rate (GPM)
Standard
Concept A
Concept B/C

Flow Test

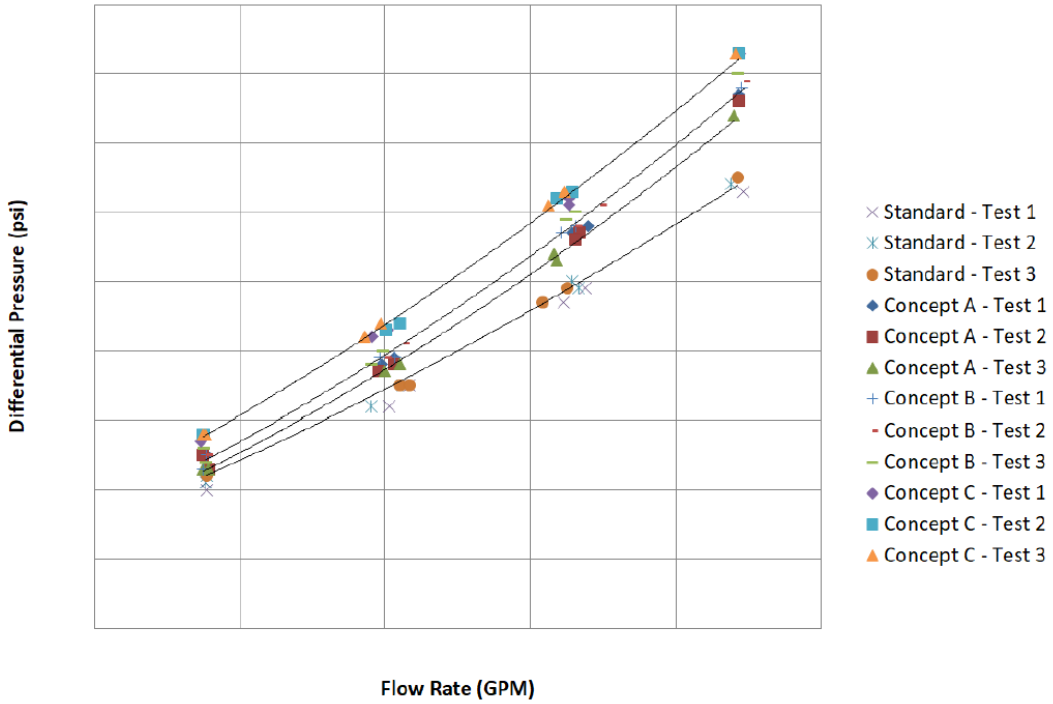
- Small flow loop for single component testing
- Room temperature
- Unpressurized
- Debris Injection System





Flow Test Results

- Each component tested three times
- CFD over-predicted pressure drop



Debris Capture Rates

- Concept A: ~50 %
- Concepts B & C: ~80 %

Item	Type	Length (mm)	Diameter (mm)	Width (mm)	Thickness (mm)	Quantity
1	Wire	10	1.0			10
2	Wire	20	1.0			5
3	Wire	10	2.0			10
4	Wire	20	2.0			5
5	Plate	10		2.0	0.3	10
6	Plate	20		2.0	0.3	5
7	Plate	30		2.0	0.3	3
8	Plate	10		2.0	0.5	10
9	Plate	20		2.0	0.5	5
10	Plate	30		2.0	0.5	3
11	Ball		2.0			10
12	Ball		3.0			10
13	Ball		4.0			10
14	Ball		5.0			10

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Publications/Presentations

- Phase I Final Report
  - "Preliminary Research into the Viability of Additive Manufacturing of BWR Lower Tie Plates"
  - DOE-NOVATECH-18799-1
  - Submitted to: Office of Science, U.S. DOE
- Customer Presentations
  - Exelon
  - TVA
  - Duke Energy
- Provisional Patent
  - In process

Next Activities

- Benchmark small flow loop results with CFD results
- Contact fuel vendors
- Finalize Lower Tie Plate design
- Small flow loop testing
- Manufacture full-scale assembly
- Full-scale testing
- Time permitting: Upper Tie Plate

Questions?

References

1. GE14 – BWR Nuclear Fuel
   https://nuclear.gepower.com/fuel-a-plant/products/ge14
2. Fuel Review: Fuel Design Data, Nuclear Engineering International, September 2014
3. General Electric Systems Technology Manual, Chapter 2.2, Fuel and Control Rod Systems
4. Development of an Evaluation Method for Nuclear Fuel Debris – Filtering Performance; Jjoon-Kyoo Park, Seong-Ki Lee, Jae-Hoon Him; Nuclear Engineering & Technology 50 (2018) 738-744

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