

# ADDITIVE MANUFACTURING OF BWR LOWER TIE PLATES



## AMM TECHNICAL REVIEW MEETING

DECEMBER 2-3, 2020

**Award Number:** DE-SC0018799

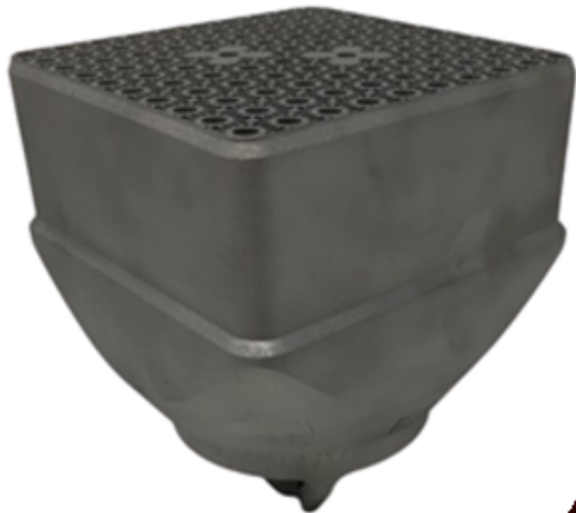
**Award Dates:** 08/2019 to 08/2021

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THIS PRESENTATION INCLUDES NOVATECH PROPRIETARY INFORMATION



# Acknowledgement and Disclaimer

**Acknowledgment:** This material is based upon work supported by the U.S. Department of Energy, Office of Science under Award Number DE-SC0018799.

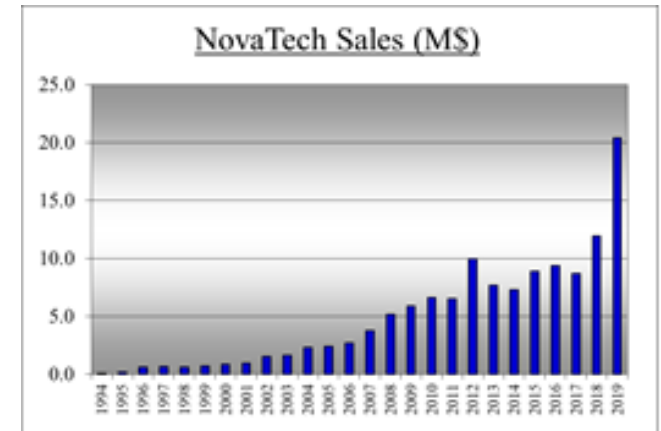
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# Agenda

- NovaTech Overview
- Project Objectives
- Technical Progress/Accomplishments
- Project Impacts
- FY-20 Milestones and Deliverables
- Issues and Concerns
- FY-21 Milestones and Deliverables
- Possible Areas for Adoption
- Q&A

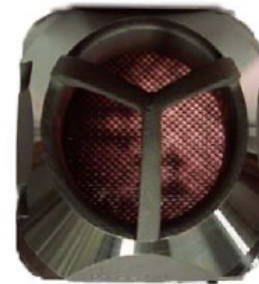
# NovaTech Introduction

- Founded in 1994
- Located in Lynchburg, VA
- 43 employees; 27,500 ft<sup>2</sup> Facility
- Small Business Classification
- Quality Assurance Program Compliant with:
  - ASME NQA-1
  - 10CFR50 Appendix B
- Registered with:
  - US Department of State (ITAR)
  - US/Canada Joint Certification Office
- Special Programs Capability (inactive currently)



# Project Objectives

- Additively manufacture (AM) a monolithic Boiling Water Reactor (BWR) Lower Tie Plate.
  - Reduce part count by combining parts
    - Nose piece
    - Tie plate with debris filter
    - Channel seals
  - Maintain Interfaces
    - Channel
    - Core Plate
  - Improve performance
    - Debris capture
    - Pressure drop
  - Utilize geometries that were previously not manufacturable
    - Torturous path

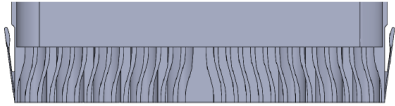
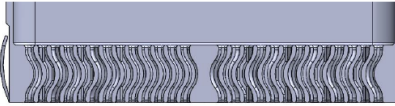
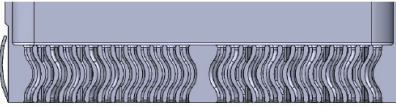
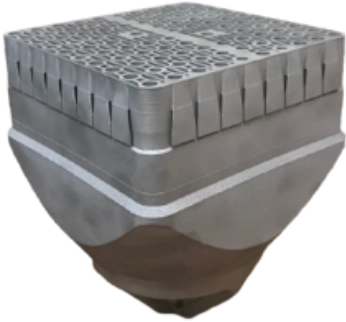




GE14 [1]

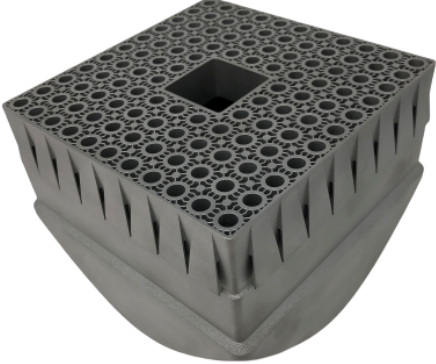
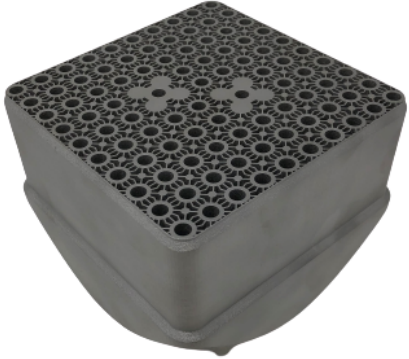
# Technical Progress/Accomplishments

- Designed multiple monolithic Lower Tie Plates
- Additively Manufactured six Lower Tie Plates
- Upgraded small flow loop
- Designed and fabricated test box for large flow loop
- Designed and fabricated simulated BWR fuel assembly
- Performed benchmark testing of small flow loop
- Performed testing on 10X10 design in small flow loop

# Lower Tie Plate Concepts – Phase I

Concept	A	B	C
Design Basis	G14	GE14	GE14
Torturous Path	Single Hump	Double Hump	Double Hump
Bypass Hole	Teardrop	Double Hump	Double Hump
Channel Seal	Flat Cantilever	Curved Cantilever	Curved Cantilever (mod)
Qty Printed	1	1	1
Flow Path Cross Section			
Picture			

# Lower Tie Plate Concepts – Phase II

Concept	D	E
Design Basis	ATRIUM 11™	GNF2
Torturous Path	Twisted Radial	Twisted Radial
Bypass Hole	Double Hump	Double Hump
Channel Seal	Flat Cantilever	None
Qty Printed	1	2 (1 Inconel 718, 1 Stainless)
Flow Path Cross Section	[Proprietary]	[Proprietary]
Picture		



# Small Flow Loop

- Capabilities
  - 150 GPM
  - Cold Flow
  - Unpressurized

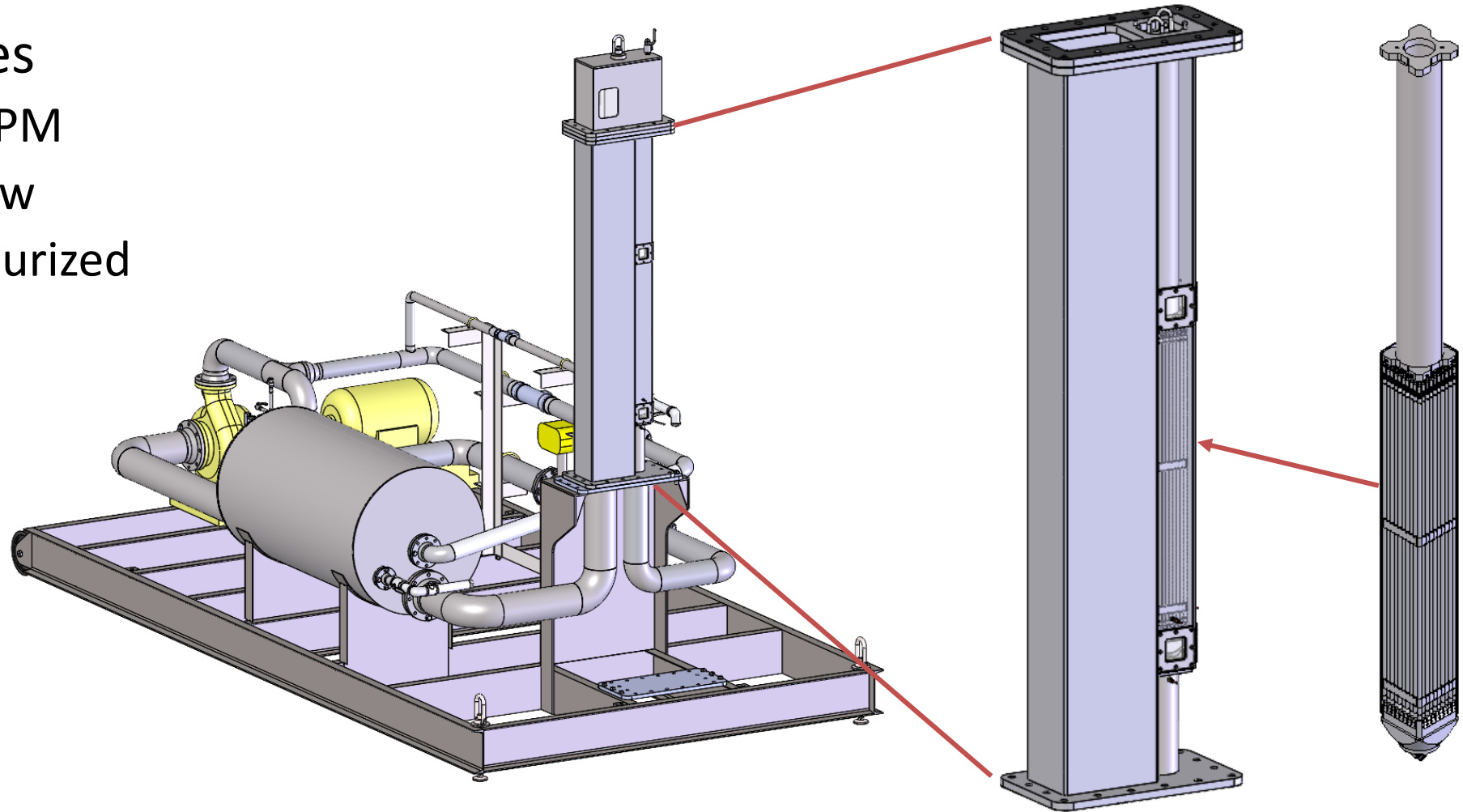


Three Test Sections

Pressure Port

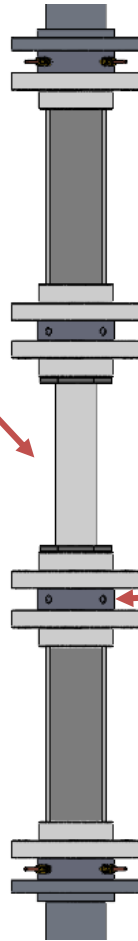
# Large Flow Loop

- Capabilities
  - 2,000 GPM
  - Cold Flow
  - Unpressurized



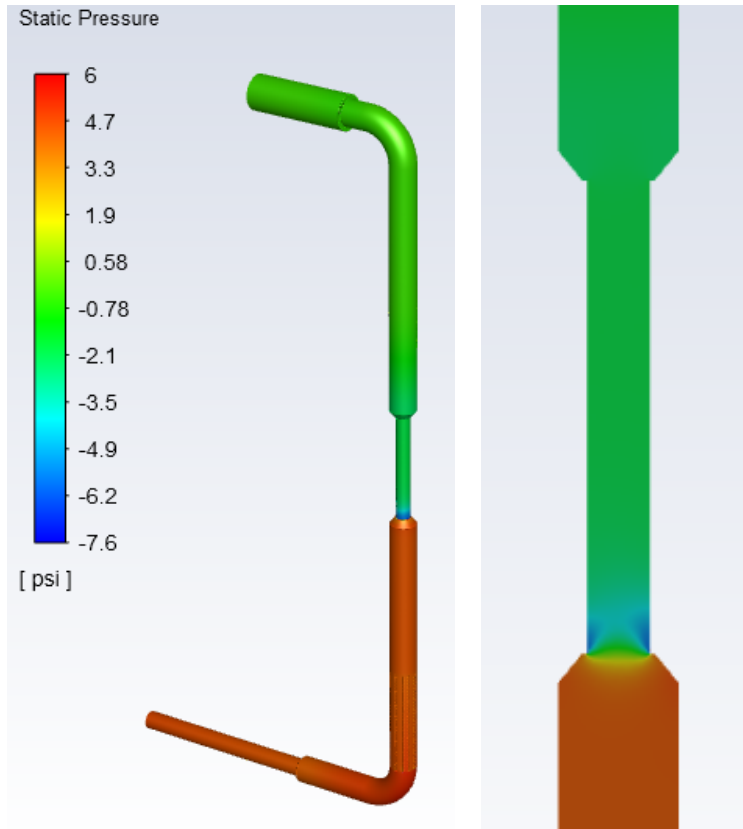
# Benchmark Testing

- Three diameters
  - 2.00 Pipe
  - 1.50 Pipe
  - 1.25 Pipe
- 5X5 Sample
  - 3.00 Pipe
  - Sample between first and second sections

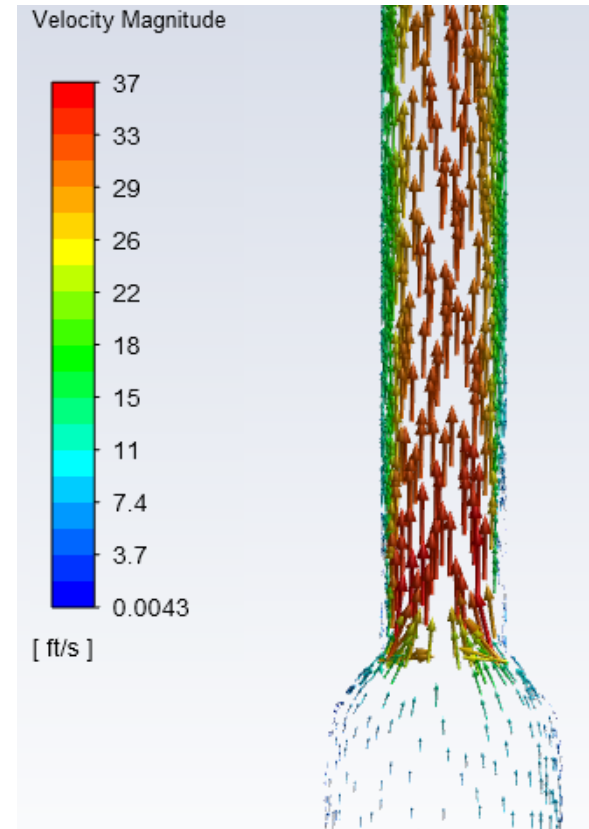


# CFD Example: 1.50 Pipe @ 160 GPM

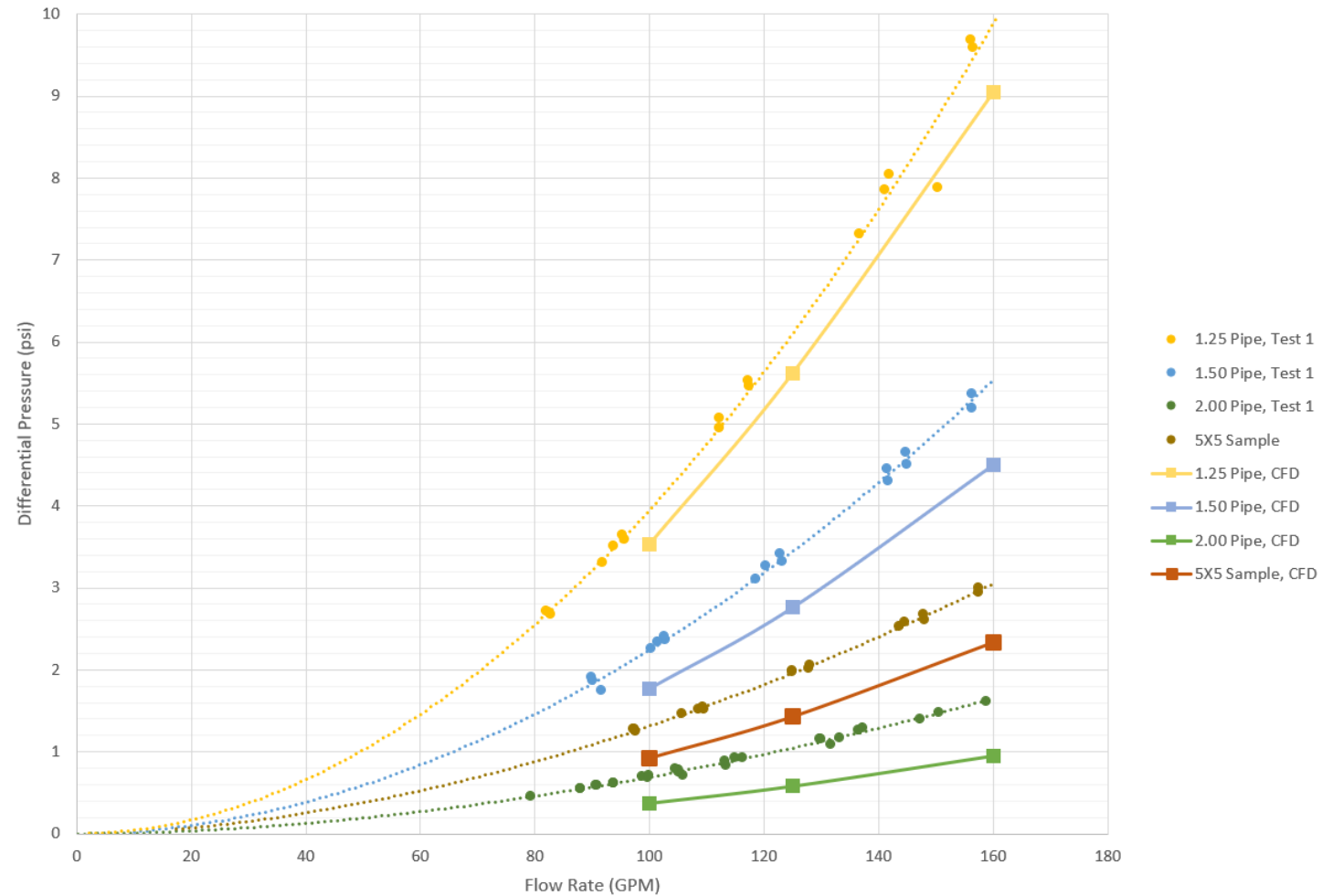
## Pressure



## Velocity



# Benchmark Test v. CFD Results



# Lower Tie Plate Test Equipment



Standard



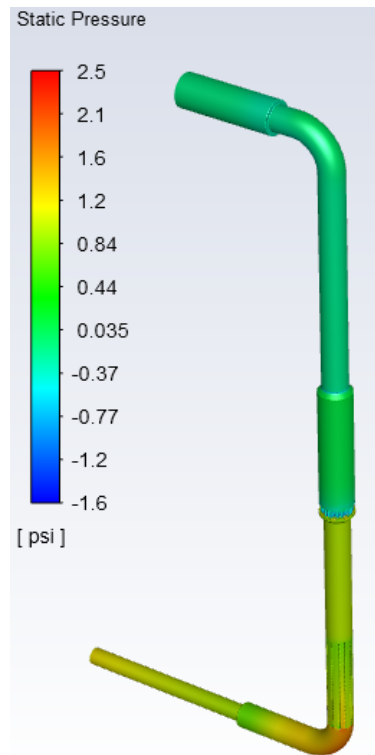
Lower Tie Plate with Fuel Rods  
and Upper Tie Plate



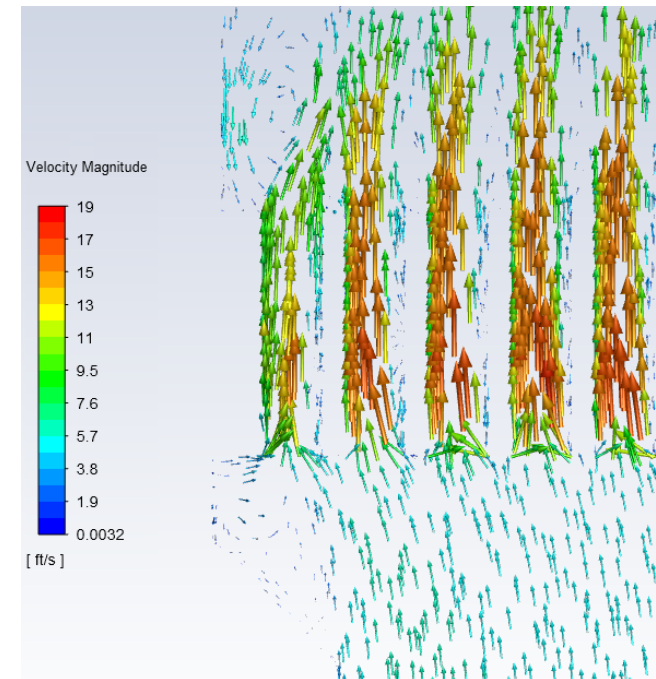
Test Box

# CFD Example: Standard @ 160 GPM

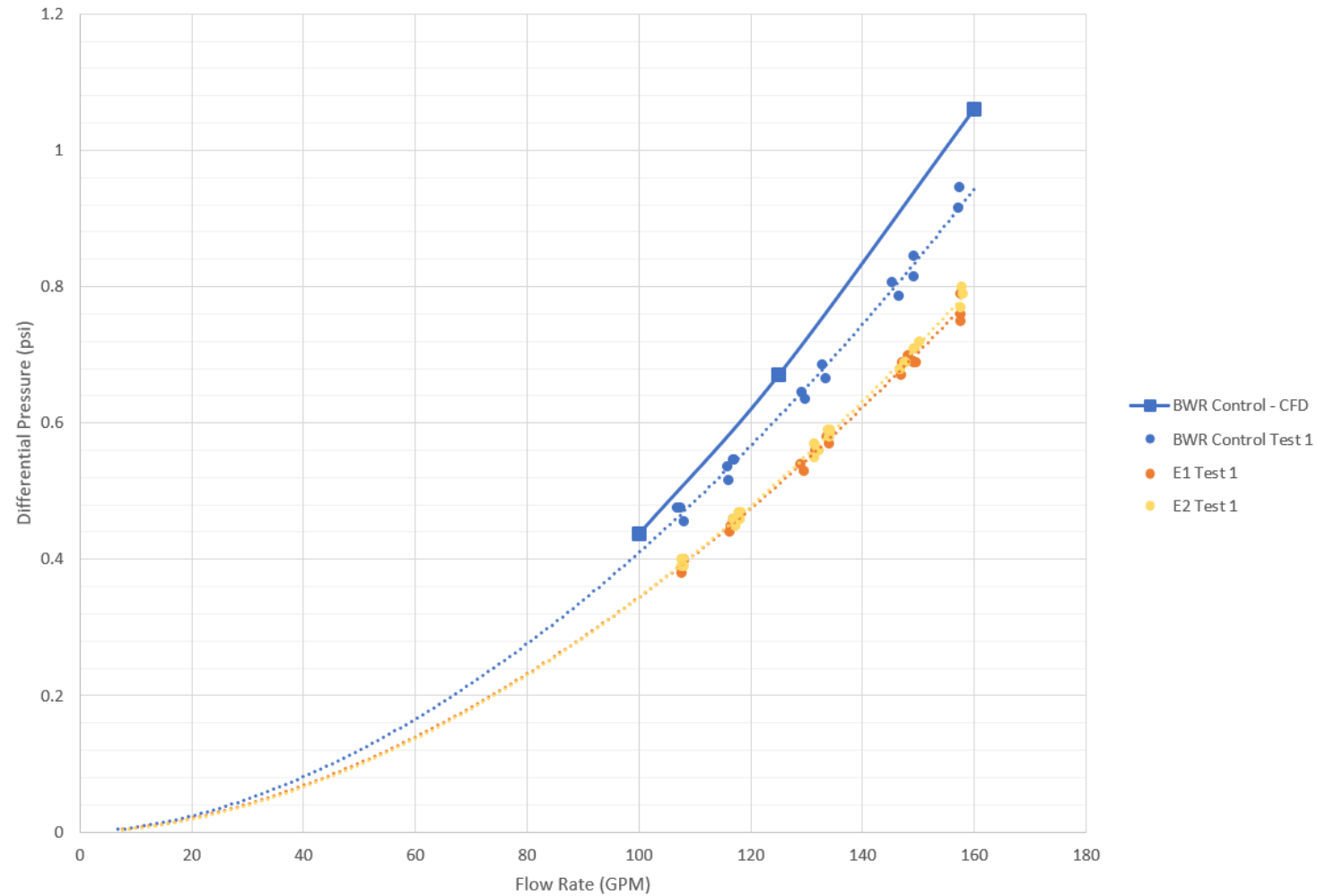
## Pressure



## Velocity



# Lower Tie Plate Pressure Drop Data

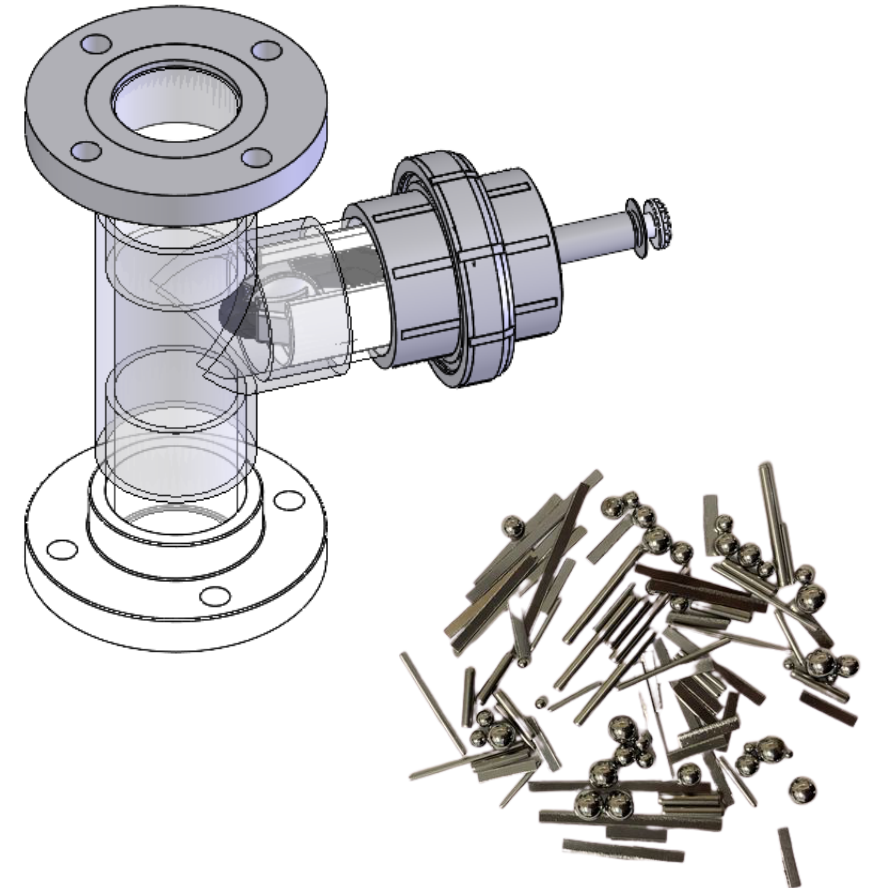




# Debris Testing

Item	Type	Length (mm)	Diameter (mm)	Width (mm)	Thickness (mm)	Starting Quantity	Concept E1 Captured	Concept E2 Captured
1	Wire	10	1			10	8	3
2	Wire	20	1			5	5	5
3	Wire	10	2			10	10	10
4	Wire	20	2			5	5	5
5	Plate	10		2	0.3	10	10	9
6	Plate	20		2	0.3	5	5	5
7	Plate	30		2	0.3	3	3	3
8	Plate	10		2	0.5	10	10	7
9	Plate	20		2	0.5	5	4	5
10	Plate	30		2	0.5	3	3	3
11	Ball		2			10	10	6
12	Ball		3			10	10	10
13	Ball		4			10	10	10
14	Ball		5			10	10	10

Total	106	103	91
Capture Rate		97%	86%



# Project Impacts

- Conferences
  - Virtual TechConnect Conference – November 17-19, 2020
- Presentations
  - Utilities: Exelon, TVA, Duke Energy
- Collaborations
  - Meeting with Framatome
- Commercialization
  - Working with LARTA for applications outside of nuclear

# Milestones and Deliverables for FY-20

Milestone/Deliverable	Status	Comments
Lower Tie Plate Designs	Complete	
Fabricate Lower Tie Plates	Complete	
Upgrade Small Flow Loop	Complete	
Design/fabricate Test Boxes for Small Flow Loop	In Progress	10X10 complete, working on 11X11
Design/fabricate Test Box for Large Flow Loop	Complete	
Design/fabricate Simulated BWR Fuel Assembly	In Progress	Parts complete, need to assemble
Small Flow Loop Bench Testing and CFD	In Progress	Further CFD evaluation
10X10 Small Flow Loop Testing and CFD	In Progress	Working on Lower Tie Plate CFD

# Issues and Concerns

- Lack of interest in emerging BWR technologies
  - Potential collaboration with Framatome
  - Investigate needs for SMR technologies

# Milestones and Deliverables for FY-21

Milestone/Deliverable	Completion Date	Comments
11X11 Testing in Small Flow Loop	1/2021	
10X10 and 11X11 FA Testing in Large Flow Loop	1/2021	
Design/fabricate additional Lower Tie Plates	3/2021	Incorporate radial torturous path on bypass flow holes; adjust flow path for various pressure drops
Testing of new designs in Small Flow Loop	4/2021	
Inspect Reliability of AM Parts	4/2021	
1,000 Hour Life and Wear Test	7/2021	
Final Report	8/2021	

# Possible Areas for Adoption

- The AM Lower Tie Plate is designed to replace lower tie plates on the existing BWR fuel assembly design
  - Pressure drop can be adjusted for specific plants
  - High debris capture rate
- Technology can also be applied to new SMR designs
- TRL 4

# Contact Information and Questions



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# References

[1] <https://nuclear.gepower.com/fuel-a-plant/products/ge14>