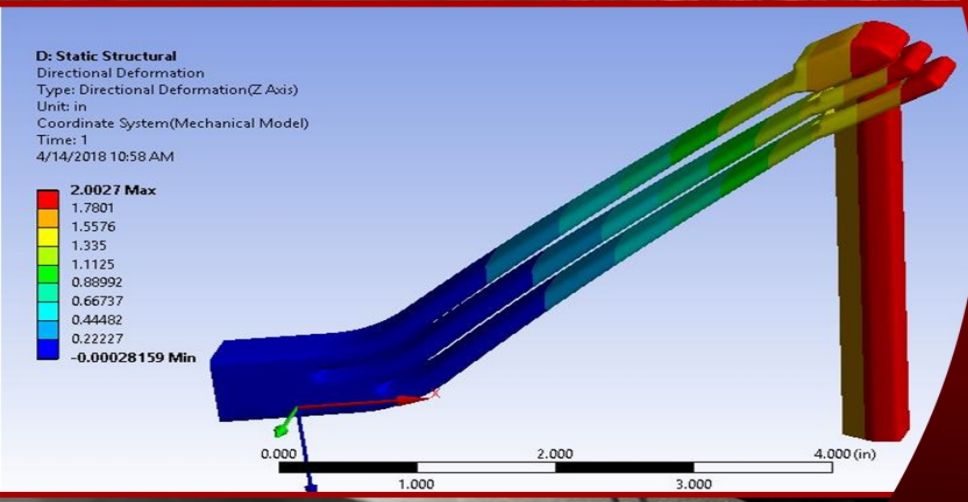

ADDITIVE MANUFACTURING OF SMR HOLDDOWN SPRINGS AND UPPER NOZZLE INTERFACES

RESEARCH PERFORMANCE PROGRESS REPORT December 2020

Award: DE-SC0017990

Award Dates: 8/27/2018 through 12/31/2020

Presented by:
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AMM
Advanced Methods for Manufacturing

NOVATECH
Innovative Technologies International

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-SC0017990.

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Project Objectives

- Design an AM replacement for a Westinghouse style nuclear fuel assembly holddown spring
  - Minimize the number or parts
  - Match the current spring's load-deflection curve
  - Maintain interfaces
    - Handling equipment, control components, reactor internals, etc.
  - Ensure loose part control
  - Maintain spring integrity
    - Minimize strain
    - Maintain Low Cycle Fatigue (LCF) performance
    - Maintain Stress Corrosion Cracking (SCC) performance

*

*Palheiros, Franklin L., "Analyzing Linear Elastic Fracture Toughness (LEFM) on a Fuel Assembly Hold Down Spring", College of Mechanical Engineering, University of South Carolina, 2007.

NOVATECH

Technical Progress / Accomplishments

- Designed several one-piece AM holddown springs that meet the design requirements
- Fabricated multiple prototype springs
- Optimizing the AM fabrication process for the AM spring
  - Part orientation to optimize spring performance
  - Minimize cost
  - Fabrication consistency
- Performed load-deflection tests (additional slides)
- Performed LCF tests (additional slides)
- Performing SCC tests (additional slides)
- Developing part qualification program

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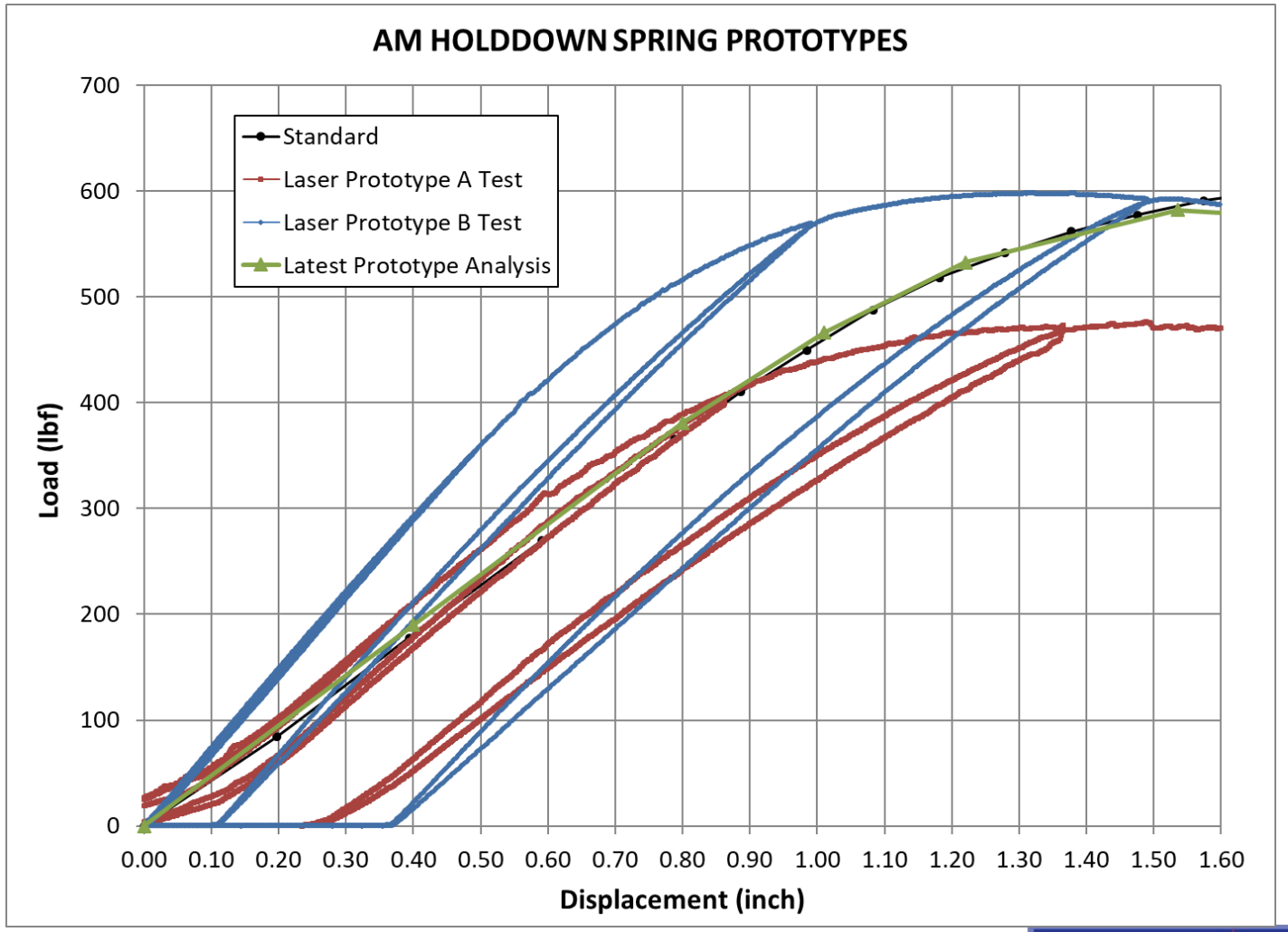
Technical Progress / Accomplishments
Load-Deflection Tests



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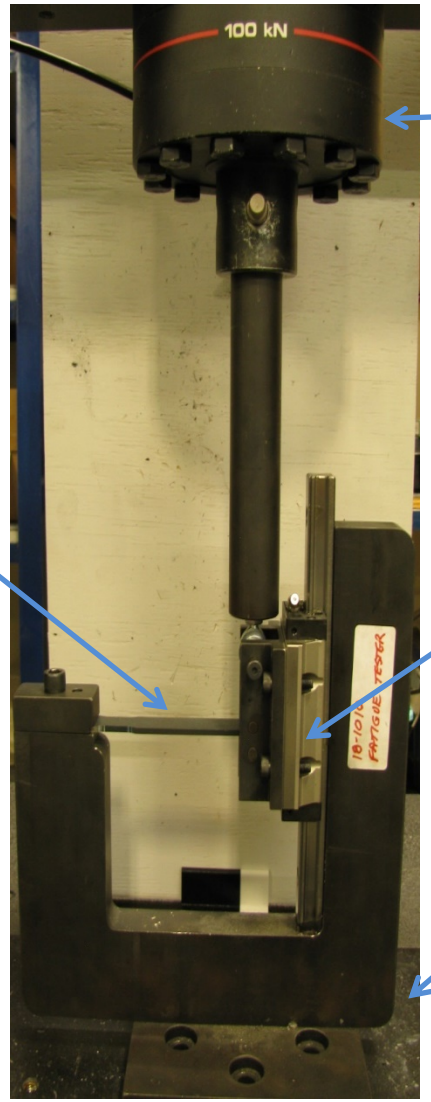
Technical Progress / Accomplishments
Low Cycle Fatigue



INSTRON LOAD CELL

TEST SPECIMEN

TEST DISPLACEMENT SLIDE

INSTRON BASE PLATE

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Technical Progress / Accomplishments
Low Cycle Fatigue

- Custom NovaTech specimen design.
- 1/8” X 3/4” X 5”
- Designed to simulate actual spring geometry and loadings.

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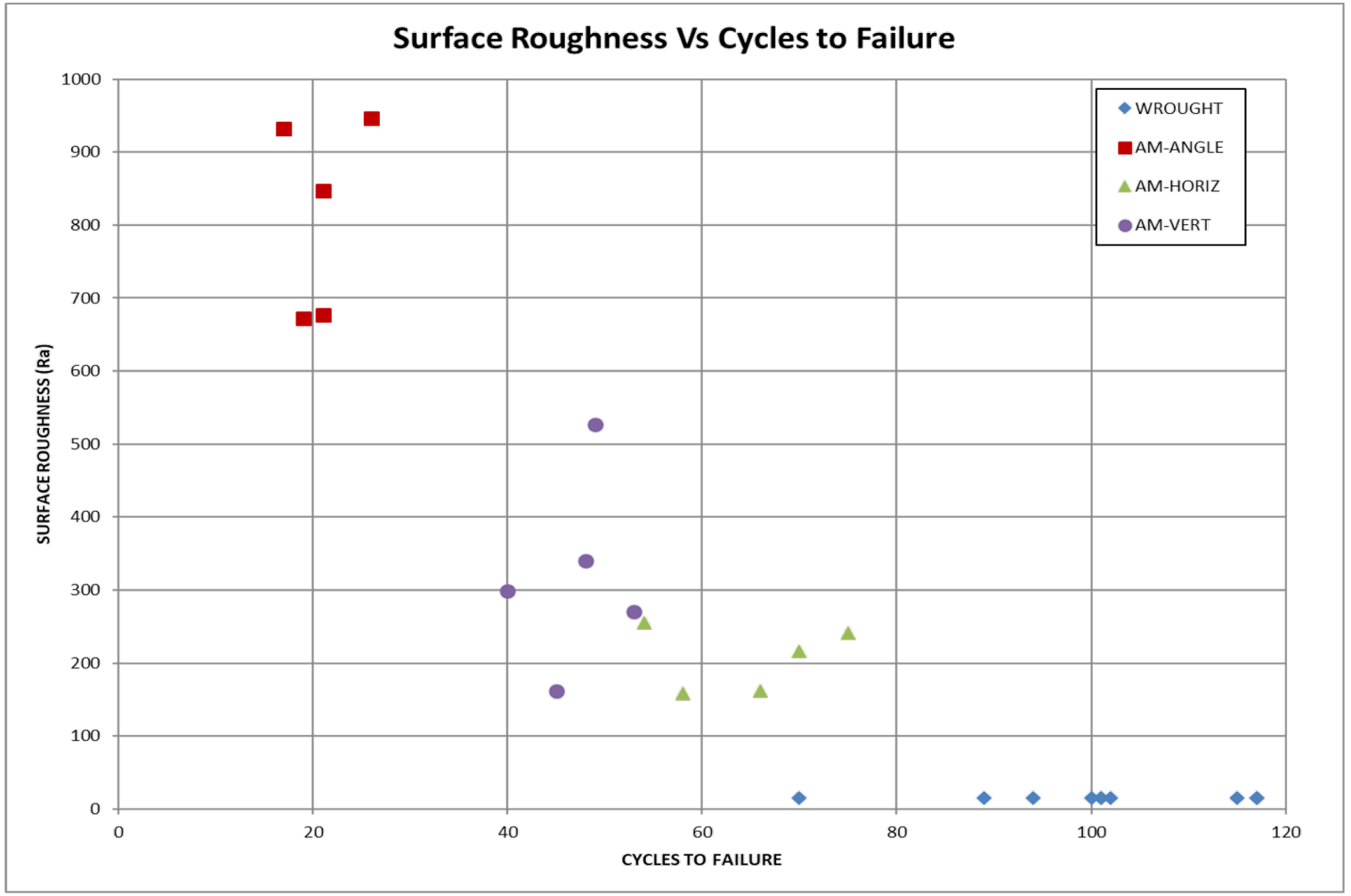
Technical Progress / Accomplishments
Low Cycle Fatigue – First Specimens



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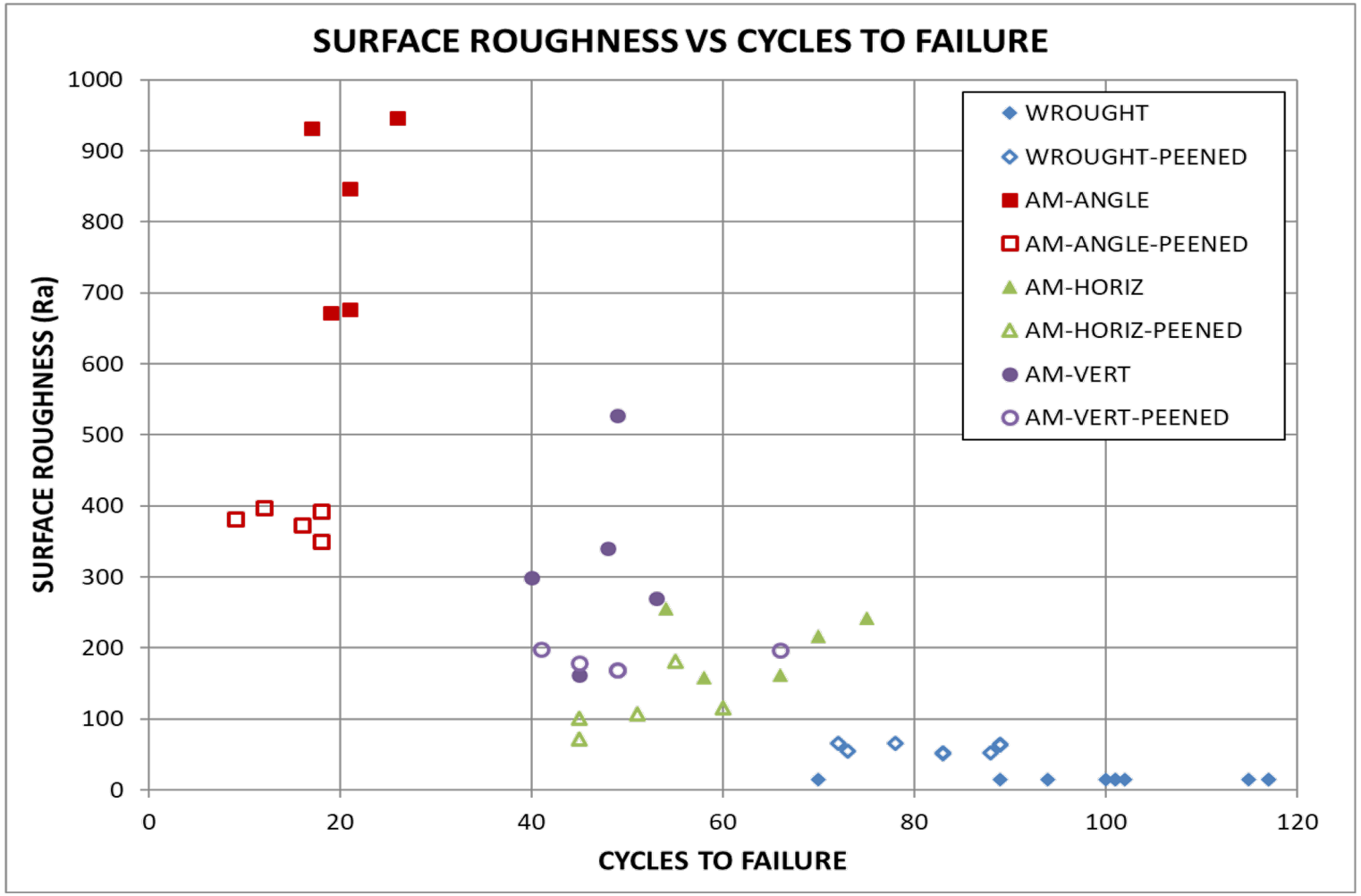
Technical Progress / Accomplishments
Low Cycle Fatigue - Peening



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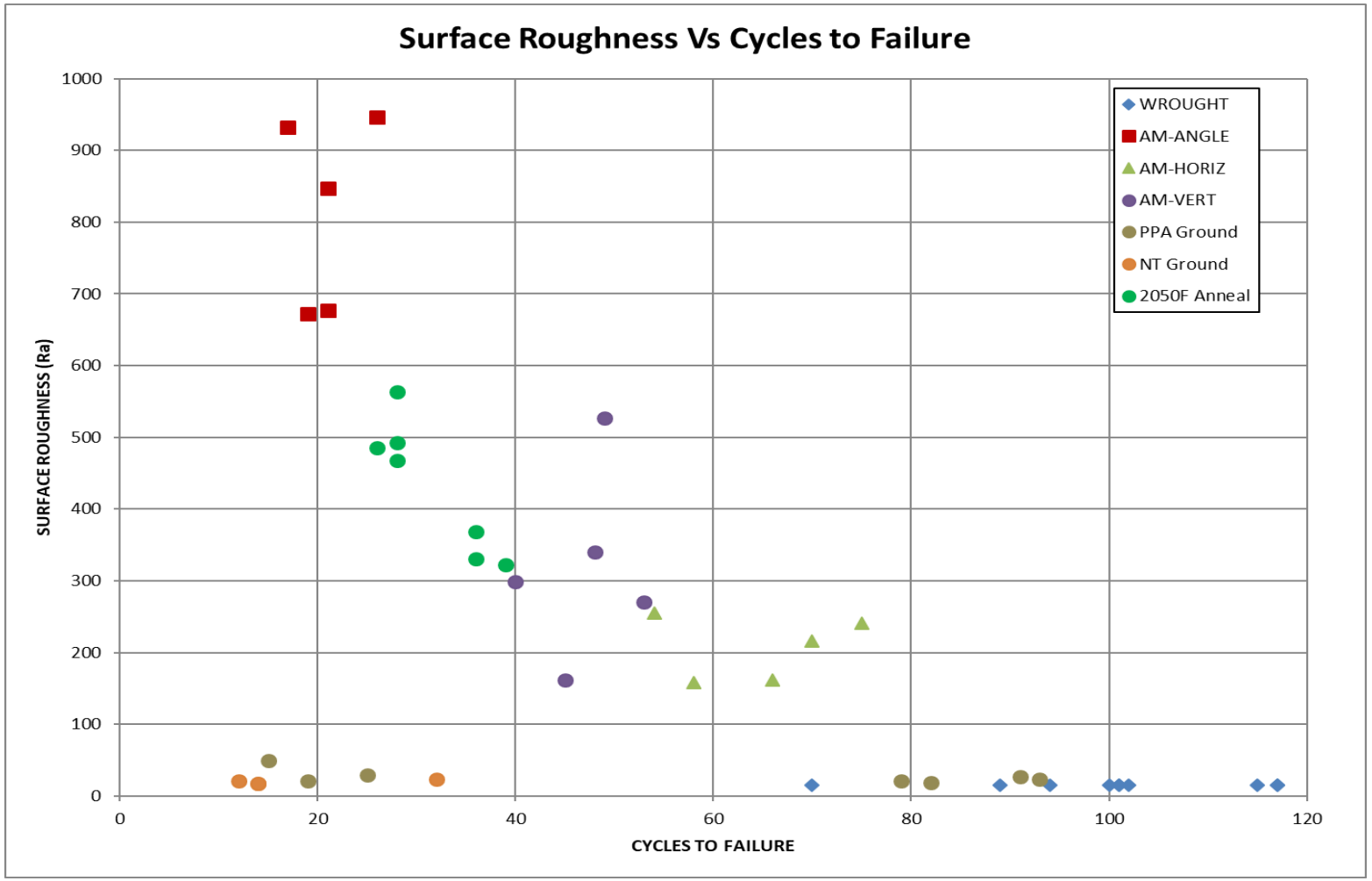
Technical Progress / Accomplishments
Low Cycle Fatigue – H/T - Grinding

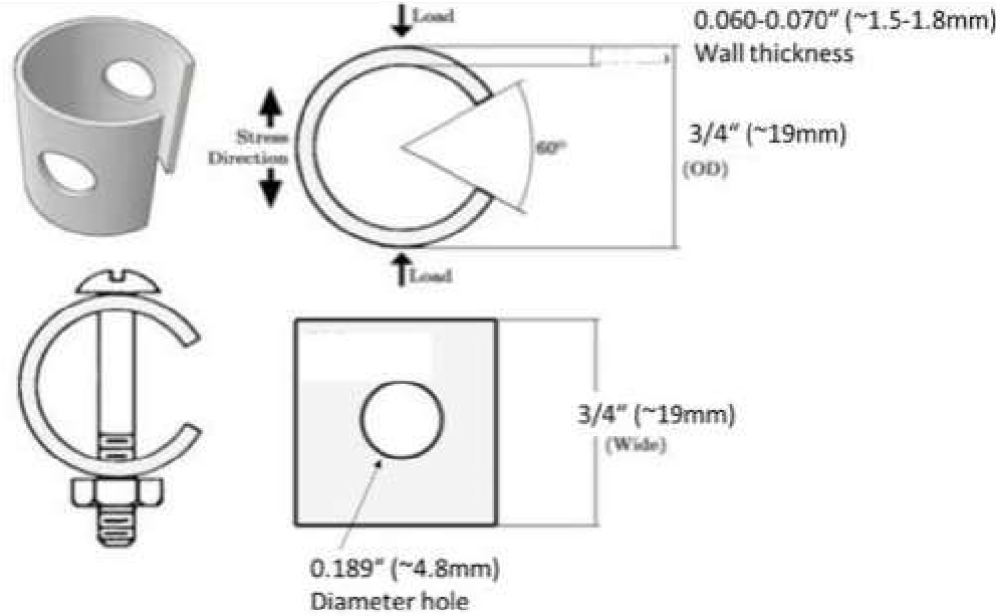


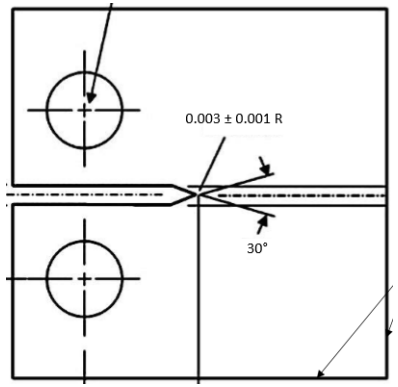
Technical Progress / Accomplishments
Low Cycle Fatigue – Future

- HIP + Grit Blast samples
- Grit Blast only samples
- HIP only samples
- DECI Duo samples
- DLyte samples
- Bel Air Tumbled samples

Technical Progress / Accomplishments

- Performing SCC tests – University of Florida
  - ASTM G-38 C-Ring Specimens
  - Autoclave testing
    - Simulated PWR environment
    - Wrought and AM samples
    - Variety of heat treatments
- Performing SCC tests – Virginia Tech
    - ASTM E647
    - Constant strain testing
    - Simulated PWR environment





Project Impacts

- Presentation to Liberty University discussing AM low cycle fatigue.
  - Discussing further collaboration utilizing the capabilities of their Center for Engineering, Research, and Education (CERE).
- Presentation to Virginia Tech
  - Proceeding with SCC testing utilizing their testing capabilities.
- Collaborating with innoVAMPP
  - Dr. Owen Hildreth – Colorado School of Mines
- Presentation to the Naval Surface Warfare Center
- Working with NovaTech Sales to move our AM expertise beyond the nuclear market.
  - Working with LARTA to evaluate additional markets.

Project Impacts

- Staying in contact with Framatome and Westinghouse.
- Evaluating membership with Nuclear Energy Institute
  - Attending their Advanced Reactor Working Group Meeting on December 15th.
- Evaluating membership with MOST-AM
  - Dr. Albert To, University of Pittsburgh

Milestones and Deliverables for FY-20

Milestone or Deliverable	Status	Comments
Holddown Spring Design Requirement Document	Complete	
Holddown Spring Design	Complete	Several different successful designs. Final fabrication and testing underway.
Production	On-going	Multiple prototypes fabricated.
Bench Testing	On-going	Load deflection testing, LCF testing, SCC testing
Full Scale Testing	Future	Assemble a complete top nozzle with springs and flow test
Final Report	Future	

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Milestones and Deliverables for FY-20

- No cost extension requested
  - Original due date August 31, 2020
  - First extension to December 31, 2020
  - New extension request to Spring 2021

Issues and Concerns

- Covid
- Time – no cost extension requested

Possible Areas for Adoption

- The AM holddown spring is designed to replace holddown springs on Westinghouse style fuel assemblies
  - 3-leaf and 4-leaf designs
  - 15X15 and 17X17 array fuel assemblies
  - Can be custom tailored to individual reactors to match fuel assembly lift (+ margin)
  - Can be used to minimize fuel assembly bow by providing a custom spring that does not provide more holddown force than necessary.
    - Improved fuel handling which reduces the risk of torn grids that can lead to fuel rod failures.
    - Improve margin to incomplete rod insertion (IRI).
- TRL 5

Contact Information and Questions

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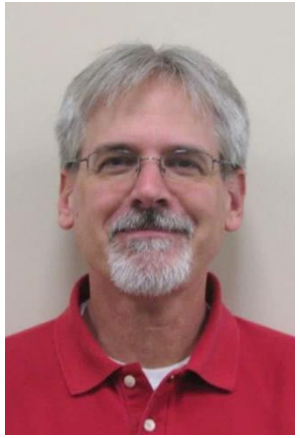

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