



National Aeronautics and
Space Administration



Fission Surface Power (FSP) Project

Radiation Testing of Radiator Working Fluids & Stirling Converter Organic Components

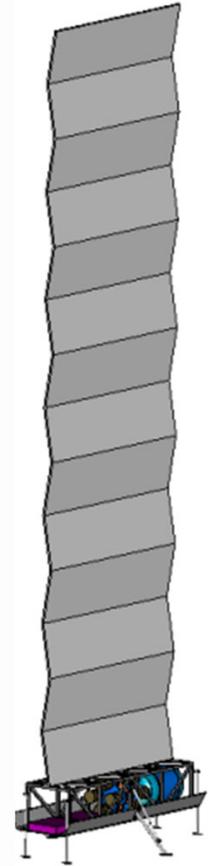
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Fission Surface Power (FSP) Project Overview



- NASA and DOE are collaborating on development of a 40 kWe fission reactor technology demonstration to be deployed on the Moon in the early 2030s for a future Mars mission
- Phase 1 Design Requirements include:
 - Minimum end-of-life 40 kWe continuous power output for at least 10 years
 - Radiation exposure to be limited to 5 rem per year above lunar background 1 km away from the reactor
- Glenn Research Center (GRC) is home of the FSP project and is the leading institution overseeing FSP technology maturation and risk reduction efforts



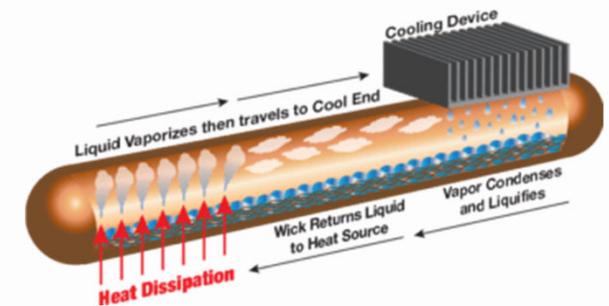
FSP Concept (Reactor Pallet)

FSP Technology Maturation



Radiator Heat Pipe Working Fluids

- FSP requires radiators to regulate temperature
- Heat pipes are a method of passive heat transfer that utilize a working fluid's phase transformation
- Titanium heat pipes with water as a working fluid have been proposed for radiators; however, water freezing is a risk
- Alternative working fluids have been proposed but their radiation tolerance is unknown



Generic heat pipe model



Copper heat pipes

FSP Technology Maturation



Stirling Engine Organics

- Stirling engines have long been studied to provide a means of converting nuclear thermal energy to electrical due to their high efficiency [1]
- Polymer/organic based materials have been observed to degrade in radiation (cross-linking, scissioning, & outgassing) [2]
- The organic components of Stirling engines need to be studied under FSP induced radiation conditions



Stirling engine test at GRC



O-ring radiation damage [3]

[1] Schreiber, Jeffrey G. "Summary of Stirling Converter Testing at NASA Glenn Research Center," 2006.

[2] Mireles, Omar R. "Experimental Demonstration Of Radiation Effects On The Performance Of A Stirling-alternator Converter And Candidate Materials Evaluation," 2010.

[3] Shin, E. Eugene. "Evaluation and Validation of Organic Materials for Advanced Stirling Convertors (ASCs): Overview." 2015.

<https://www.nasa.gov/centers-and-facilities/glenn/stirling-converter-sets-14-year-continuous-operation-milestone/>

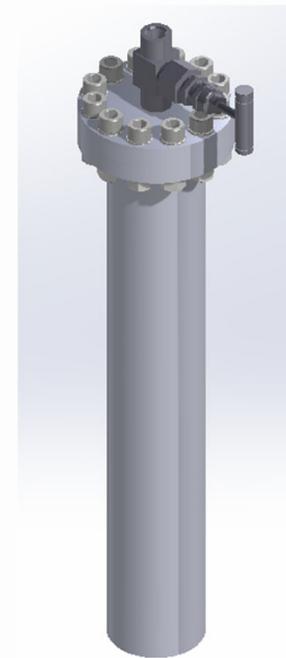
Summer Internship Project



Internship Objective:

Design a test apparatus to enable the irradiation of Stirling organics and heat pipe working fluids in a research reactor under prototypic pressures and temperatures

- Stirling organics will be tested at 3 different temperatures and exposed to anticipated neutron and gamma doses
- Three different heat pipe working fluids will be irradiated while transferring heat



Stirling Organics
Helium Pressure Vessel

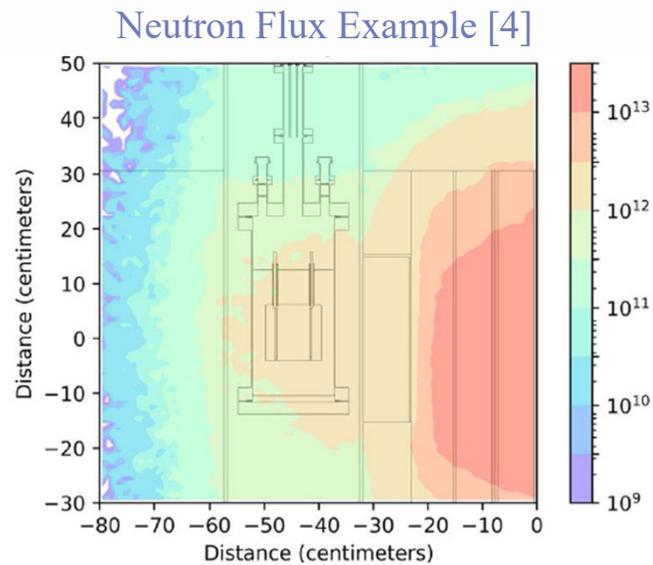


Radiator
Heat Pipe

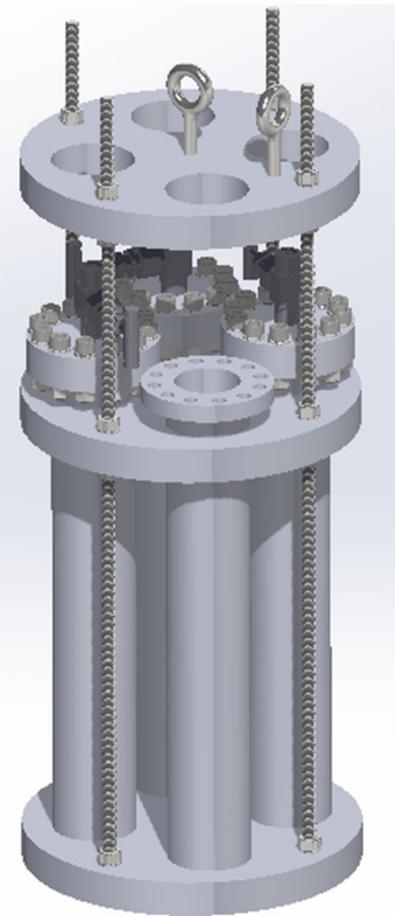
Test Apparatus Design



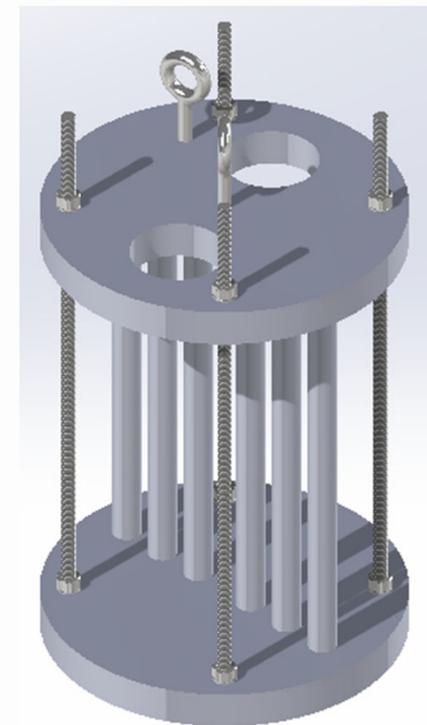
- Baskets are designed to lower pressure vessels and heat pipes into a research reactor for irradiation



Pressure Vessel Basket



Heat Pipe Basket



Future Work & Acknowledgements

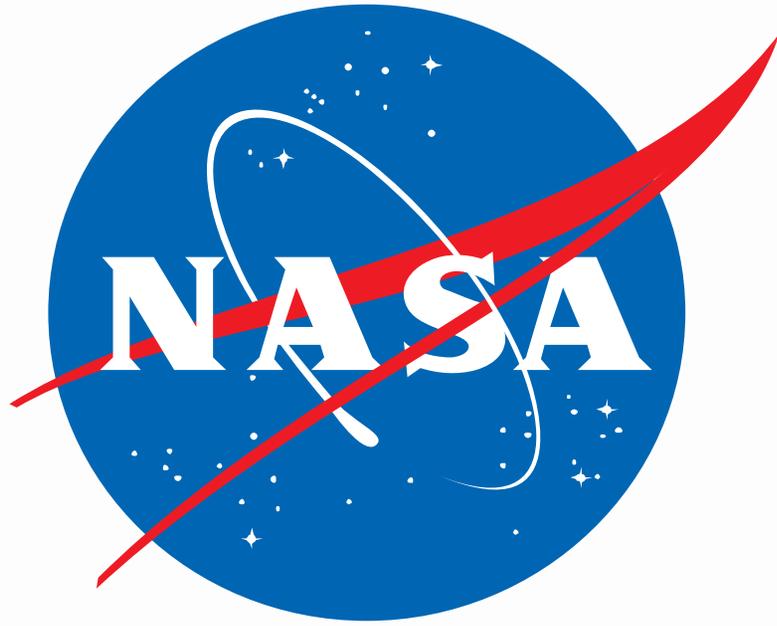


Future Work

- Structural & Thermal Modeling
- Radiation transport and activation analysis
- Pre-test organic characterization
- Irradiation test
- Post Irradiation Examination (PIE)

Acknowledgements

- Thank you to my mentor Tyler Steiner and to the entire FSP project group for supporting my project and funding my travel



References



1. Schreiber, Jeffrey G. “Summary of Stirling Converter Testing at NASA Glenn Research Center,” 2006.
2. Mireles, Omar R. “Experimental Demonstration Of Radiation Effects On The Performance Of A Stirling-alternator Converter And Candidate Materials Evaluation,” 2010.
3. Shin, E. Eugene. “Evaluation and Validation of Organic Materials for Advanced Stirling Convertors (ASCs): Overview.” In 13th International Energy Conversion Engineering Conference. Orlando, FL: American Institute of Aeronautics and Astronautics, 2015. <https://doi.org/10.2514/6.2015-3904>.
4. Hutchins, Emily, Lawrence Heilbronn, Brandon Wilson, and N. Dianne Ezell. “Low-Cost, Modular High-Temperature Irradiation Testbed for NTP Material Testing.” In Nuclear and Emerging Technologies for Space (NETS 2023), 50–54. Idaho Falls, ID: American Nuclear Society, 2023. <https://doi.org/10.13182/NETS23-41916>.