MICR
DOE MICROREACTOR PROGRAM

MRP

# Single Primary Heat Extraction and Removal Emulator (SPHERE)

*Thermal Testing Capability to Enable Microreactors*

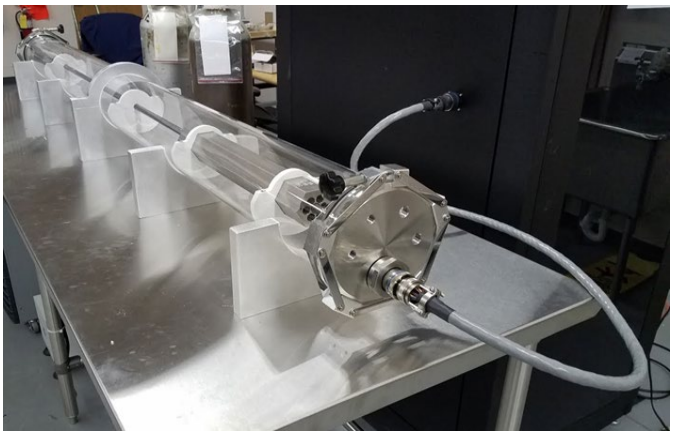
The U.S. Department of Energy (DOE) Microreactor Program supports research and development (R&D) of technologies related to the development, demonstration, and deployment of very small, factory fabricated, transportable reactors to provide power and heat for decentralized generation in civilian, industrial and defense energy sectors.

Led by Idaho National Laboratory, the program conducts both fundamental and applied R&D to reduce the risks associated with new technology performance and manufacturing readiness of microreactors. The intent is to ensure that microreactor concepts can be developed, licensed, and deployed by commercial entities to meet specific use case requirements.

The program coordinates work and activities across participating laboratories, universities, and industry as well as other DOE programs. Participating national laboratories are Argonne National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory and Sandia National Laboratory.

## What is the Single Primary Heat Extraction and Removal Emulator (SPHERE)?

The DOE Microreactor Program is developing a non-nuclear thermal- and integrated system testing, for better understanding of thermal performance of the heat pipe under a wide range of heating values and operating temperatures, further enhancing understanding of heat pipe startup and transient operation.



*SPHERE test bed and seven-hole test article*

*SPHERE:*

Will provide a facility and capability for researchers and technology developers to test non-nuclear thermal and integrated systems, for better understanding of thermal performance of heat pipe.

SPHERE will support non-nuclear thermal and integrated systems testing, for better understanding of thermal performance of the heat pipe under a wide range of heating values and operating temperatures, further enhancing understanding of heat pipe startup and transient operation.

The initial testing consisted of vacuum operation of a sodium heat pipe. The temperature was measured at 10 evenly spaced points along the heat pipe. Additional exterior thermocouple measurements were also taken on the exterior of the heat pipe to confirm the similarity of thermowell temperatures to exterior heat pipe temperature measurements.

The initial tests were successfully completed, and results measured at INL are consistent with the data from the manufacturer. In future, the experimental group will be performing calorimetric measurements with water-cooled gas gap calorimeter, determining heat pipe operational limits, and testing under both air and inert gas conditions.

## How will SHPERE be used to support microreactor development?

SHPERE can be broadly used to test microreactor structures and subsystems. Specific examples include:

- **Provide capabilities to perform steady state and transient testing of heat pipes and heat transfer.** Wide range of heating values and operating temperatures and observe heat pipe startup and transient operation.
- **Develop effective thermal coupling methods** between the heat pipe outer surface and core structures.
- **Measure heat pipe axial temperature profiles** during startup, steady-state, and transient operation using thermal imaging and surface measurements.

## What are the design specifications for SPHERE?

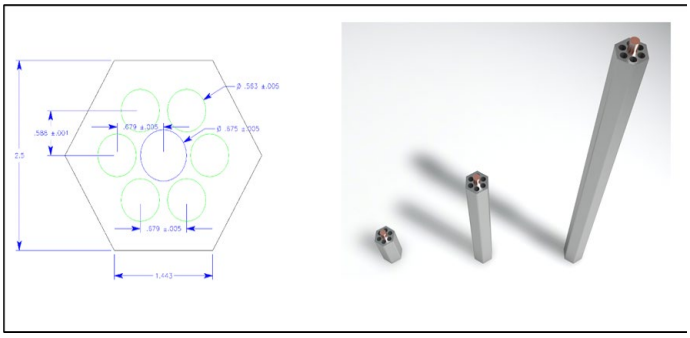
***Test chamber characteristics include:***

- Vacuum (10-4 torr) or inert gas
- 8 ft long × 6 in. diameter quartz tube
- Flanges for gas flow connections and instrumentation feedthrough ports

*Electrical heating capability requires:*

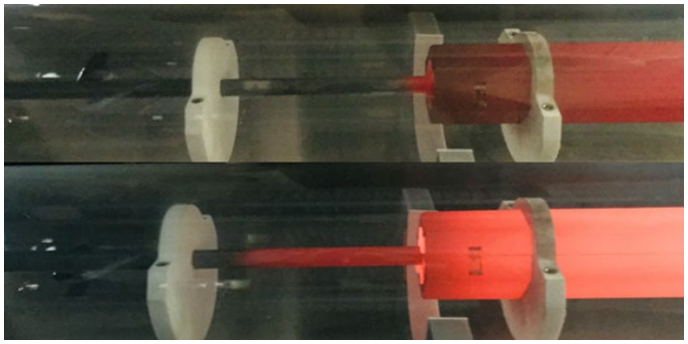
- A test bed designed for up to 20 kW electrical power to heaters
- Maximum test article temperature of 750˚C
- Heat rejection through passive radiation or coupled with a water-cooled gas gap calorimeter.

| Parameter | Value |
|---|---|
| Length | 243 cm |
| Diameter | 15 cm |
| Tube material | Quartz |
| Connections | Flanged for gas flow and instrumentation feed through |
| Maximum power | 20 kW |
| Max Temperature | 750 C |
| Heat Removal | Passive radiation or water-cooled gas gap calorimeter |



*SPHERE cross-section geometry of a seven-hole core block for the single heat pipe experiment (6 in., ½ m., 1 m), not to scale.*

Below is the SPHERE image of the heater test and initial short heat pipe operation during initial testing.



*SPHERE image of heater test and initial short heat pipe operation*

## SPHERE – Current Experiments Plans

- Perform test for gap conductance testing
- Long-term operation and validation of system durability
- Coupling with advanced heat removal technologies with condenser HX coupling
- Testing of components made with additive manufacturing methods

MRP Microreactor Program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