

Database of Previous Research Supporting Microreactor Designs

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September 2018



**Prepared for the
U.S. Department of Energy
Office of Nuclear Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517**

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Database of Previous Research Supporting Microreactor Designs

Introduction

This report provides a list of previous research supporting microreactor designs. For the purposes of this report, a “microreactor” will be defined as a reactor designed to produce less than 20 MW thermal while ensuring that the system is factory manufacturable, transportable (via truck, rail, or aircraft), and maintains neutronic simplicity (e.g., external controls) that can enable safe operation under semi-autonomous or autonomous operation. The 20 MW thermal limit is based on the U.S. Department of Energy limit for a Hazard Category 2 (per 10 CFR 830 and DOE-STD-1027). Above the Hazard Category 2 limit, licensing activities would be required to be more detailed and robust. This does not eliminate higher-than-Hazard Category 2 reactors from consideration, but an increase in requirements typically means increased cost and time for development. Similarly, neutron simplicity is vital for minimizing the number of on-site operators; in turn, this enhances cost-competitiveness. Complicated designs do not eliminate reactors from inclusion in this report.

A transportable reactor will be further defined using the Army Reactor Program definition. A “mobile” reactor is one that is moved as a single unit (reactor at a minimum, but can include power-conversion and heat-rejection systems together). A “portable” reactor is one that is moved in several pieces and assembled on site. The reactor may include separate items to assemble on-site, such as a pressure vessel, fuel, etc. Power-conversion and heat-rejection systems would also be transported separately.

Using these definitions, the potential types of microreactor designs are presented. A rationale for the types of documents included in this report is provided. This report is envisioned to be a living document in that it will be updated as new information becomes available.

Types of Microreactor Designs

Reactors are grouped by heat-removal attributes of the reactor. Heat removal (sometimes along with fuel type) is a convenient way to group reactors of similar technology.

Types of portable reactor technologies include:

- High-temperature gas-cooled reactors with TRISO fuels
- Sodium-cooled fast reactors
- Lead fast reactors
- Molten salt reactors.

Types of mobile reactor technologies include:

- Heat-pipe-cooled reactors
- High-temperature gas-cooled reactors with TRISO fuels (possibly moderated to reduce size).

Documents Included

Many portable reactors are being developed by miniaturizing larger Generation IV advanced-reactor concepts that were designed to produce hundreds of megawatts. Some noteworthy examples are:

- U-Battery Micro Modular Reactor (URENCO, UK), StarCore Nuclear (Starcorenuclear, CA), and Ultra Safe Nuclear Micro Modular Reactor (USNC, US) that use microencapsulated fuels cooled by high-temperature helium
- 4S Reactor (Toshiba, JP), and LeadCold (Swedish Advanced Lead Reactor, SW)

They will not be included in this report simply because the research is vast, and other parts of the Advanced Reactor Technology (ART) program are addressing underlying R&D needs.

The two concepts in the mobile category do not have an organized categorization of the literature describing the fundamental research supporting the designs or information on the designs. Providing a start on that categorization is the goal of this document.

The research areas presented include:

- Heat-pipe-cooled reactors. Two commercial US companies (Oklo, Inc., and Westinghouse Electric Corporation) are currently advancing heat-pipe-based micro-modular reactors for deployment. Their proprietary designs are controlled information and could not be presented in this document. As a result generic heat-pipe reactor design and development information is presented here as follows:
 - General heat-pipe research
 - General heat-piper reactor design
 - Hydride moderators.
- Gas-cooled TRISO-fueled reactors. Two US vendors, Holos Gen and USNC, are developing what are advertised to be mobile gas-cooled reactors. Open literature on the Holos design is listed. Little, if any design information relevant to the USNC design is available in the public forum.
 - Hydride moderators.

Finally, documents of general importance to military-reactor applications are included.

General Alkali Metal Heat Pipe Literature

Since their invention in 1964 by Grover et al, there are literally thousands of reports and articles on heat pipes—ranging from the commercial electronic industry to space exploration. The focus of this summary is theory, modeling, engineering of alkali metal (K, NaK, Na and Li) heatpipes.

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