# Experimental Study and Computational Modeling of P-LOFC and D-LOFC Accidents in the Fast Modular Reactor Consisting of Silicon Carbide Composite Rods

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**ABSTRACT:**

The gas-cooled fast reactor (GFR) system, one of the Generation-IV reactor concepts, is a high-temperature helium-cooled fast-spectrum reactor with the advantages of fast-spectrum systems for long-term sustainability of uranium resources and waste minimization, high thermal cycle efficiency in power conversion, and flexibility of providing high-temperature nuclear process heat. General Atomics Electromagnetic Systems (GA-EMS) is developing a new 100 MWth fast modular reactor (FMR) under the U.S. Department of Energy's (DOE's) Advanced Reactor Demonstration Program.

One of the major design differences in the FMR from the thermal-spectrum high-temperature gas-cooled reactors (HTGRs) is the lack of large core thermal inertia since HTGRs typically employ large quantities of graphite in the core region. This may lead to relatively faster reactor responses to transients and accidents in the FMR. In addition, the average core power density of the FMR is about 2.3 times that of the GA's gas-turbine modular helium reactor (GT-MHR). The FMR core coolant channel geometry is also different from that in the prismatic HTGR designs. To assure the peak fuel temperature has a sufficient margin to its melting point and the cladding has a sufficient margin to its thermal degradation point in the FMR, several key transients and accident scenarios will need to be systematically evaluated during reactor design process. These may include the depressurized loss of forced cooling (D-LOFC) due to breaks (or multiple small breaks) on the primary system and pressurized loss of forced cooling (P-LOFC) due to failure or trip of the helium circulator. Under both scenarios, natural circulation (NC) flow is expected to develop, more specifically, a global NC flow between the reactor core and reactor cavity in D-LOFC accidents and an internal NC flow inside the reactor vessel in the P-LOFC (An internal NC flow may also develop in the reactor vessel during D-LOFC). Currently, GA-EMS plans to use a computational fluid dynamics (CFD) tool to perform NC flow analyses primarily to support FMR thermal-hydraulic design. However, due to the unique FMR fuel geometry and core and system designs, experimental testing using a scaled test facility becomes indispensable to better understand the NC phenomena in P-LOFC and D-LOFC scenarios and to provide experimental data for model validation.

The goals of this proposed research are then to better understand NC flow phenomena under both P-LOFC and D-LOFC accidents in the FMR and to improve our modeling capabilities for such accidents. The specific objectives are to:

1. Design and construct a well-scaled integral-effects test (IET) facility to study NC flows under both P-LOFC and D-LOFC accidents in the FMR;
2. Experimentally study the establishment of NC flow in the core region for a P-LOFC accident using the IET facility and the flow development in an extended P-LOFC scenario;
3. Experimentally study the complex global NC flows between the RPV and reactor cavity during D-LOFC accidents using the IET facility (with modifications from the P-LOFC setup); and
4. Develop and validate CFD and system analysis (if applicable) models for NC phenomena in both accidents.