U.S. DEPARTMENT OF ENERGY
NUCLEAR ENERGY RESEARCH INITIATIVE
ABSTRACT

PI: **Donald McEligot** **Proposal No.: 99-0254**

Institution: **Idaho National Engineering and Environmental Laboratory**

Collaborators: **Iowa State University, University of Maryland, General Atomics, University of Manchester-UK, Tokai University-Japan, Toyama University-Japan**

Title: **Fundamental Thermal Fluid Physics of High Temperature Flows in Advanced Reactor Systems**

The objective of this proposed laboratory/university/industry collaboration of coupled computational and experimental studies addresses fundamental science and engineering to develop supporting knowledge required for reliable approaches to new and advanced reactor designs for improved performance, efficiency, reliability, enhanced safety and reduced costs and waste and for small reactors for remote power and hydrogen generation. It will provide basic thermal fluid science knowledge to develop increased understanding for the behavior of fluid systems at high temperatures, application and improvement of modern computation and modeling methods and incorporation of enhanced safety features. The project promotes, maintains and extends the nuclear science and engineering base to meet future technical challenges in design and operation of high efficiency reactors, low output reactors and nuclear plant safety; it brings recognized thermal fluid mechanics authorities, Profs. Pletcher and Wallace and their students, into the nuclear science and engineering research community. This basic thermal fluids research applies first principles approaches (Direct Numerical Simulation and Large Eddy Simulation) coupled with experimentation (heat transfer and fluid mechanics measurements). Turbulence is one of the most important unresolved problems in engineering and science, particularly for the complex geometries occurring in advanced reactor systems and their passive safety systems. Prof. Pletcher will extend LES to generic idealizations of such geometries; Profs. Satake and Kunugi will support these studies with DNS. Prof. Wallace will develop miniaturized multi-sensor probes to measure turbulence components in high temperature flows. INEEL will conduct experiments on the effects of fluid property variation at high temperatures as well as obtaining fundamental turbulence and velocity data for generic idealizations of the complex geometries of advanced reactor systems. Prof. Jackson will conduct measurements of the effects of buoyancy forces on flow in circular tubes and annuli. Dr . Shenoy and his co-workers at General Atomics will provide thermal-hydraulic data needs for Modular Helium Reactors (MHR) and will apply the results of the proposed studies to realistic designs for advanced gas-cooled reactors using the closed Brayton cycle for higher thermal efficiency.

The unique INEEL Matched-Index-of-Refraction flow system, the World's largest such facility . will be applied for the first time to obtain fundamental data onflows through complex geometries important in the design and safety analyses for advanced reactors. Successful completion of the

proposed work will provide the following new fundamental and engineering knowledge, which is not presently available in the literature:

- Time-resolved basic measurements of turbulence quantities (e.g.. turbulence kinetic energy and Reynolds stresses) in internal gas flows with large property variation.

- Time-resolved data plus flow visualization of turbulent and laminarizing phenomena in accelerated flow around obstructions (spacer ribs) in annuli.

- Separation of effects of phenomena -- buoyancy, property variation and acceleration -- occurring in strongly-heated gas flow to evaluate their individual importances and consequent flow behavior (by application of LES and DNS since this separation is not feasible in experiments with gases at appropriate conditions).

- Application of DNS and LES for the first time to complex turbulent flows occuring in advanced reactors

- Fundamental data of internal turbulence distributions for assessment and guidance of CTFD codes proposed for design and safety analyses for advanced gas-cooled reactors

- Evaluation of candidate CTFD codes by applying those data.