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

PI: **L. Mason** **Proposal No.: 99-0094**

Institution: **Pacific-Sierra Research**

Collaborators: **University of Virginia, University of Maryland**

Title: **Innovative Chemithermal Techniques for Verifying Hydrocarbon Integrity in Nuclear Safety Materials**

The reliable and safe operation of nuclear power plants is predicated upon the functional integrity of many diverse types of materials. One class of materials, hydrocarbons or polymers, fulfills vital functions in critical safety systems. These systems include electric cable insulation, lubricants, O-rings, and gasket seals. Harsh radiation, thermal, and mechanical stresses accelerate the aging of these components putting them at risk for premature and catastrophic failures. To mitigate these risks, advanced technologies are required to both assess the current condition of the material and predict its useful remaining life. These monitoring technologies should be sensitive to performance degradation and should be deployed in an overall system architecture that intelligently addresses the health and usage of each specific material.

Pacific-Sierra Research Corporation (PSR), the University of Virginia (UVA), and the University of Maryland (UMD) have created a world class team that combines the best of private industry, nationally renowned scientists, and academic scholars to address this problem. The proposed effort exploits the chemithermal (suitable for chemical and thermal analysis) properties of these materials and uses a family of emerging technologies centered on oxidation induction in hydrocarbon materials. This engineering research proposal is submitted in the Fundamental Science and Technology category and is directly relevant to the materials and chemical sciences program objectives as well as the broader category of nuclear safety.

Sustenance of the nuclear power industry in the United States relies on the development of new advanced reactor designs and on the ability to maintain and extend the operation of existing nuclear power plants during the critical transition period of the next 20 to 30 years. Within 5 years, the industry will begin to lose electric production capacity due to the expiration of original 40-year operating licenses. Even if a suite of new plants were ordered today, a significant deficit in electric power will occur unless existing plant operations licenses are re-certified and extended. Without viable methods to assure the condition and remaining life of critical hydrocarbon materials such as cable insulation, operating extensions will not be possible and this will create a severe obstacle to revitalizing the country's nuclear energy infrastructure.

The process of measuring the chemithermal property of oxidative stability in hydrocarbons has the real potential for meeting the challenges of material condition monitoring and life-assessment. Unlike conventional methods which intrusively measure mechanical properties (e.g., elongation-to-

rupture, viscosity), oxidation induction methods measure the more sensitive chemithermal properties in a nearly non-destructive manner. Our early research shows that Oxidation Induction Time (OIT) can even be used as an early indicator of an ensuing complete catastrophic failure of mechanical performance.

We propose a 3-year engineering research effort to systematically investigate the utility of oxidation induction technology as a material condition monitoring and life assessment tool. This effort builds on our early research for the U.S. Department of Energy (NE) to apply OIT to polymer cable insulation. The proposed work is dedicated to expand knowledge of this emerging technology in three applications: (1) lubricants used in major nuclear power plant components; (2) O-rings and seals on critical safety-related components; and (3) electric cable insulation used for safety-related control. Our personnel are world pioneers of this technology and the collaborative team climate provides vast resources necessary to allow this research to meet the program objectives.