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REPORT ON HIGH ENERGY ARCING FAULT EXPERIMENTS

Experimental Results from Medium-Voltage Bus Duct and Switchgear Enclosures

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Final Report

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Abstract

This report documents an experimental program designed to investigate high energy arcing fault (HEAF) phenomena for medium-voltage, metal-enclosed bus ducts and switchgear. This report covers full-scale laboratory experiments using representative nuclear power plant (NPP) three-phase electrical equipment. Electrical, thermal, and pressure data were recorded for each experiment and documented in this report. This report covers experiments performed on two medium-voltage switchgear units and eight non-segregated phase bus ducts. The data collected supports characterization of the medium-voltage HEAF hazard, and these results will be used to complement the data used for HEAF hazard modeling tools and support potential improvements in fire probabilistic risk assessment (PRA) methods.

The experiments were performed at KEMA Labs in Chalfont, Pennsylvania. The experimental design, setup, and execution were performed by staff from the NRC, the National Institute of Standards and Technology (NIST), Sandia National Laboratories (SNL) and KEMA Labs. These experiments were sponsored by member countries of the HEAF 2 international agreement under the auspices of the Organisation for Economic Co-operation and Development (OECD).

The HEAF experiments were performed between August 22 and September 2, 2022. The HEAF experiments were performed on two near-identical units of General Electric metal-clad medium-voltage switchgear and eight units of non-segregated phase bus duct. A three-phase arcing fault was initiated on the equipment's bus bars. These experiments used nominal system voltages of either 4.16 kV (AC) or 6.9 kV (AC). Arc durations in the experiments ranged from approximately 2 s to 4 s with fault currents ranging from approximately 28 kA to 32 kA. Real-time electrical operating conditions, including voltage, current, and frequency, were measured during the experiments. Heat fluxes and incident energies were measured with plate thermometers and slug calorimeters at various locations around the electrical enclosures. Particulate samples were taken for subsequent analysis. The experiments were documented with normal and high-speed videography, infrared imaging, and photography.

Insights from the experimental series include timing information related to enclosure breach, event progression, mass loss measurements for electrodes and enclosures, peak pressure rise, along with visual and thermal imaging data to better understand and characterize the hazard. These results will be used to evaluate the adequacy of existing HEAF hazard modeling tools and for potential improvements to fire probabilistic risk assessment methods related to HEAF.

Keywords

High Energy Arcing Fault, Arc Flash, Electrical Enclosure, Switchgear, Bus Duct, Electric Arc, Fire Probabilistic Risk Analysis, Fire Probabilistic Safety Analysis

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