SILENE Benchmark Critical Experiments for Criticality Accident Alarm Systems

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INTRODUCTION

In October 2010 a series of benchmark experiments was conducted at the Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) Valduc SILENE [1] facility. These experiments were a joint effort between the US Department of Energy (DOE) and the French CEA. The purpose of these experiments was to create three benchmarks for the verification and validation of radiation transport codes and evaluated nuclear data used in the analysis of criticality accident alarm systems (CAASs). This presentation will discuss the geometric configuration of these experiments and the quantities that were measured and will present some preliminary comparisons between the measured data and calculations.

DESCRIPTION OF THE ACTUAL WORK

Experimental Details

This series consisted of three single-pulsed experiments with the SILENE reactor. During the first experiment the reactor was bare (unshielded), but during the second and third experiments it was shielded by lead and polyethylene, respectively. During each experiment several neutron activation foils and thermoluminescent dosimeters (TLDs) were placed around the reactor, and some of these detectors were themselves shielded from the reactor by high-density magnetite and barite concrete, standard concrete, and/or BoroBond. All the concrete was provided by CEA Saclay, and the BoroBond was provided by Y-12 National Security Complex. Figure 1 is a picture of the SILENE reactor cell configured for pulse 1.

Also included in these experiments were measurements of the neutron and photon spectra with two BICRON BC-501A liquid scintillators. These two detectors were provided and operated by CEA Valduc. They were set up just outside the SILENE reactor cell with additional lead shielding to prevent the detectors from being saturated. The final detectors involved in the experiments were two different types of CAAS detectors. The Babcock International Group provided three CIDAS CAAS detectors, which measured photon dose and dose rate with a Geiger-Müller tube. CIDAS detectors are currently in use at Y-12 in the newly constructed Highly Enriched Uranium Materials Facility. The second CAAS detector used a ^{6}LiF TLD to absorb neutrons and a silicon detector to count the charge particles released by these absorption events. Lawrence Livermore National Laboratory provided four of these detectors, which had formerly been used at the Rocky Flats facility in the United States.

Fig. 1. SILENE reactor cell, pulse 1 configuration.

Computational Evaluation Details

The evaluation of these benchmark experiments is also a joint effort between DOE and CEA. The experiments are being modeled in the United States using the CAAS modeling capability [2] of the MAVRIC [3] sequence in SCALE [4] and with MCNP [5]. The French are modeling the experiments using TRIPOLI-4 [6]. This presentation will primarily focus on the progress of the US modeling efforts.

Computationally, on the US side these experiments are initially being modeled in two steps. The first step is to calculate the spatial and energy-dependent source distribution for each critical configuration of SILENE, which has been done using the KENO-VI [7] eigenvalue code. These source distributions are then used in a fixed source code (Monaco [3] or MCNP) to calculate the response of the detectors in the experiments. Future modeling activities may include calculating the source distribution with MCNP, calculating the detector responses with the MCNP eigenvalue kcode, and/or modeling the experiments with a deterministic transport code (Denovo [8] or PARTISN [9]).

RESULTS

At this time the dosimetry (neutron activation and TLD) for the first experiment has been released preliminarily to the participants of the experiments and benchmark evaluators. This presentation will show comparisons between the US computational results calculated for the first pulse and the first pulse measured data. Issues encountered during the experiments and so far during the computational analysis along with the resulting lessons learned will also be discussed. The ultimate goal of this work is to produce a benchmark of sufficient quality to be published in the ICSBEP handbook. This benchmark will be the first CAAS/shielding benchmark published in the ICSBEP handbook that has a highly enriched uranium pulsed critical source that is representative of a criticality accident.

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