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**ORNL
FOREIGN TRIP REPORT
TA 371474**

DATE: March 31, 2015

SUBJECT: Report of Foreign Travel to Geel, Belgium – Klaus H. Guber, Reactor and Nuclear Systems Division

TO: Jerry N. McKamy, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511/GTN, 1000 Independence Ave., SW, Washington, DC 20585-1290

FROM: Klaus H. Guber

**MEETING:
TITLE** N/A

**MEETING:
LOCATION** Institute for Reference Materials and Measurements (IRMM), Geel, Belgium

**MEETING:
DATES** 2/6/2015 – 3/13/2015

**ATTENDEES:
ON BEHALF
OF NCSP** Klaus H. Guber

**MEETING:
BENEFIT TO
NCSP** Dr. Guber is a nuclear data specialist who has experience in nuclear data measurements, and he traveled to Geel, Belgium to perform neutron cross-section measurements using the Geel Electron Linear Accelerator (GELINA) at IRMM. The measurements have been performed in accordance with the Nuclear Criticality Safety Program (NCSP) Five Year Plan, and the measurements provide needed nuclear data for the NCSP.

PURPOSE: The primary purpose of the travel is to perform nuclear cross-section measurements at the Institute for Reference Materials and Measurements (IRMM) in Geel, Belgium. The primary objective is to complete neutron cross-section measurements on vanadium (V) at IRMM. Furthermore, additional work includes data reduction tasks for previous measurement campaigns in October-November 2014 for vanadium (V) transmission and neutron capture cross-section at IRMM. All of these work tasks have been performed for the NCSP, and the nuclear data measurement work is performed in collaboration with IRMM of the Joint Research Institute of the European Community.

**SITES:
VISITED** IRMM at the Joint Research Institute of the European Community, Geel, Belgium

ABSTRACT: The traveler visited IRMM in Geel, Belgium. At IRMM, the objective of the visit is to initiate neutron transmission and capture cross-section measurements for V using the GELINA facility. During the visit, the traveler performed data reduction tasks for V neutron capture data obtained through measurements with the “thin” sample as well as for the transmission data previously taken.

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REPORT OF FOREIGN TRAVEL

**Klaus Guber
Geel, Belgium**

February 06–March 15, 2015

PURPOSE OF TRAVEL

The primary purpose of the travel is to perform nuclear cross-section measurements at the Institute for Reference Materials and Measurements (IRMM) in Geel, Belgium. The primary objective of this trip is to perform and complete neutron cross-section measurements on V at IRMM. Furthermore, additional work includes data reduction tasks for previous measurement campaigns in October–November 2014 for V transmission and neutron capture cross-section at IRMM. All of these work tasks have been performed for the NCSP, and the nuclear data measurement work is performed in collaboration with IRMM of the Joint Research Institute of the European Community.

Report

Klaus Guber traveled to IRMM to perform nuclear data measurement and analysis work for the NCSP. At IRMM, the GELINA (Geel Electron Linear Accelerator) neutron facility can be used to perform neutron-induced cross-section measurements in the neutron energy range from thermal up to ~20 MeV that includes the resonance region for many isotopes/nuclides of interest to the NCSP. GELINA is similar in capability to the Oak Ridge Electron Linear Accelerator (ORELA) in the U.S.; however, ORELA is no longer available for performing neutron cross-section measurements. GELINA is a neutron source driven by a pulsed electron beam, which produces neutrons via Bremsstrahlung from a uranium target. Due to a special compression system, the accelerated electron pulse of GELINA can be compressed to one nsec pulse width at full power. In combination with a long flight path, the GELINA facility provides excellent time-of-flight (TOF) resolution, which determines the neutron energy. Therefore individual resonances of the cross section can be resolved at much higher neutron energies, and this neutron energy-resolution capability is essential for determining the detailed neutron cross-section structure for nuclides of importance to criticality safety applications.

In the course of this trip, two experiments started during the measurements campaign in October–November 2014 were continued at GELINA: First, transmission experiments to determine the transmission for the 14 mm thick V sample were continued. Second, a neutron capture measurement using a thick V sample with 80 mm diameter and 2 mm thickness was made at 60 meters on Flight Path (FP) 14 with different filter combinations. Data were obtained during the course of a 5-week measurement campaign. Note in the travel report 366866 it was erroneously reported that the thick sample was measured instead of the thin one.

Additionally, data reduction tasks were initiated at IRMM for the previous neutron capture and transmission measurements of the thin V sample. For this task, the GELINA specific software packages AGL and AGS were used. In the first step, all list mode data were converted into TOF spectra. This data conversion was completed for the sample, sample holder, open beam and different background filter configurations. With AGS, the data can be converted to cross-section data or transmission data. The GELINA data-reduction software enables the experimentalist to process all experimental uncertainties in a consistent way to produce a covariance matrix describing all experimental effects, and the experimental

covariance data are essential for supporting the cross-section covariance evaluation effort. At this stage, the data are ready for reduction to transmission or cross section, respectively.

Based on preliminary analysis of the vanadium data, the measured cross-section data are useful to support subsequent resonance evaluation work at ORNL. With the high neutron flux from GELINA using a short pulse width in combination with a long flight path, it will be possible to extend the resolved resonance region for V beyond the existing resonance evaluation limit of 212 keV. Due to the first inelastic channel opening up at 320 keV, neutron capture data can only be used up to this energy. In this high-energy region, the dominating part for neutron energy resolution is the neutron pulse width. It is expected that the measured V data will be provided to the ORNL evaluators who will prepare new resonance evaluations per the schedule in the NCSP Five-Year Plan.

During this visit, a joint JAEA - EU workshop (March, 4 – 5) on neutron resonance densitometry (NRD) was held at IRMM, which was attended by Guber. The aim of the workshop was to evaluate and demonstrate the feasibility to use neutron resonance data in combination with transmission and neutron capture experiments to analyze and quantify special nuclear material (SNM) from the Fukushima Daiichi site in Japan. In addition to presentations on the NRD and NDA technologies, it was also demonstrated that heterogeneous samples of unknown composition could be characterized by neutron transmission and neutron capture experiments if the neutron resonance parameters are well known. For this application, a neutron source with excellent neutron energy resolution is a prerequisite. It is planned to install a facility at Fukushima to analyze particle-like debris of melted nuclear fuel using NRD.

Overall, Guber's foreign travel to IRMM was very important to completing NCSP measurement and evaluation tasks as defined in the NCSP Five Year Plan.

Persons Contacted at IRMM

Peter Schillebeeckx, Host
Willy Mondelaers, Section Head NP Unit
Peter Siegler
Stefan Kopecky
Jan Heyse
Arjan Plompen

Itinerary

02/06/15 - 02/07/15	Travel from Knoxville to Frankfurt, Germany
02/07/15 - 02/08/15	Personal day in Germany
02/08/15 - 02/08/15	Travel to Geel, Belgium
02/09/15 - 03/13/15	IRMM-GELINA, Geel, Belgium
03/14/15 - 03/14/15	Personal day in Germany
03/15/15	Travel from Frankfurt, Germany to Knoxville, USA

DISTRIBUTION

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