2002

Development of Dose Conversion Coefficients for Radionuclides Produced in Spallation Neutron Sources

Phillip W. Patton
University of Nevada, Las Vegas

Mark Rudin
University of Nevada, Las Vegas

Task 7

Development of Dose Conversion Coefficients for Radionuclides Produced in Spallation Neutron Sources

P.W. Patton and M.J. Rudin

GOAL AND BACKGROUND

Ensuring the safety of workers at accelerator-driven nuclear facilities is paramount before these systems can be deployed for nuclear transmutation or any other mission. Spallation neutron sources produce as many as 660 rare radionuclides in either the target or blanket during the spallation process that are not addressed in current radiation protection standards. This research program seeks to address this problem through the generation of internal and external dose coefficients (DCs) for these "new" isotopes. This effort supports not only graduate students at UNLV, but also establishes a research consortium with representatives from several universities and national laboratories.

Dose coefficients are used by radiation safety personnel to determine the radiation dose incurred to a tissue or organ system from a given exposure. To ensure worker safety and limit exposure to radionuclides, these parameters are often expressed in terms of Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs). Results from this study will produce ALIs and DACs for those rare radionuclides created by current technology that are not included in FGR 11 (Federal Guidance Report No. 11). Additionally, DCs developed will augment radiological data in Publications 68 and 72 of the International Commission on Radiological Protection (ICRP), contributing to the safe operation of accelerator-driven nuclear systems in the United States and abroad.

OBJECTIVES

For the first year of this effort, the UNLV research team set out four objectives. First, the university and laboratory consortium had to be established. This consortium was tasked with helping to determine the methodology for determining the dose coefficients, and to ensure that the resulting DCs will be of use to the national programs developing accelerator-driven nuclear systems (such as the SNS or an accelerator-driven transmutation system) and to the health physics community as a whole. The second goal of this program was to determine a methodology and then prioritize the radionuclides so that the research effort would address the most significant radionuclides first. Working with the Georgia Institute of Technology, the UNLV team then needed to formalize the developed methodologies, and ensure that they are reproducible. The final objective for the first year of this program was to use the developed methodologies to begin generating dose coefficients.

RESEARCH ACCOMPLISHMENTS

The research consortium, consisting of university participation from the Georgia Institute of Technology, Idaho State University, Texas A&M University, University of Florida, UNLV, and Tbilisi State University in Tbilisi, Republic of Georgia was established. This core group of university partners was supplemented by representatives from Department of Energy Laboratories at Los Alamos National Laboratory (LANL) and Oak Ridge National Laboratory (ORNL). From this consortium, a working group was formed to implement the goals and objectives underlining consortium efforts.

The Dose Coefficient Working Group (DC Working Group) directs project activities, prioritized radionuclides that will be considered in this project, developed the methodologies to determine internal and external DCs, and coordinates informational exchange among participants. The DC Working Group met for the first time in Las Vegas in January 2002 and formulated an action plan for the rest of the project.

The DC Working Group developed a draft methodology to determine internal and external DCs. Radiological data was acquired from a nuclear physics database developed at Brookhaven National Laboratory. This data included decay modes, decay energy levels, and radiation energies and intensities. The data was downloaded to an input file for execution in the Dose Calculation (DCAL) program developed by ORNL. Formatting problems encountered while incorporating input files in the DCAL program are currently being addressed.

A prototype methodology to determine dose conversion coefficients for short-lived radionuclides produced in spallation neutron sources was developed by a Georgia Tech graduate student, Mr. Omar Wooten, and Tony Andrade of Los Alamos National Laboratory. Mr. Whooten put radiological data in a format that could be read by DCAL. He determined DCs for 3-4 radionuclides using this method. However, several "bugs" resided in the developed methodology and require refinement before utilization in the UNLV DC project. Mr. John Shanahan of UNLV and Mr. Whooten have been working closely together to troubleshoot computer-programming glitches and further develop the internal DC methodology.

The Working Group prioritized a group of radionuclides for DC determination. These radioisotopes were selected for prioritization because researchers expect their release following air emission or activation of a mercury target after a long irradiation period. The prioritized list was further refined to include only radionuclides with a half-life

greater than 1 minute. 120 radionuclides were identified in the priority group. These radionuclides were then assigned to the various members and groups participating in quantifying DCs. To provide a quality check on the adopted methodology, some radioisotopes were assigned to more than one team. The metabolic models and data from ICRP 30 and 66 will be used for evaluating the dose coefficients, permitting the use of the best technology available while maintaining consistency with current standards.

For consistency with Federal Guidance Report No. 11, dose coefficients will be evaluated for the following target tissues of "reference man": gonads, breast, lung, red marrow, bone surface, thyroid, and remainder of body. Additionally, the total committed effective dose equivalent (total dose incurred based on radiation type and organ type in a 50 year time frame) will be calculated. From these calculations, the ALIs and DACs can be determined.

To educate participants on the methodology used to generate internal and external dose coefficients for these select radionuclides, UNLV hosted a student workshop in May 2002 in Las Vegas. Students from UNLV, Idaho State University, Georgia Institute of Technology, along with professional staff from Tbilisi State University in Tbilisi, Georgia, attended the workshop. Dr. Keith Eckerman, the new DOE project collaborator, also attended. Following the student workshop, the DC Working Group held its second meeting. Dr. Mark Rudin of UNLV and Dr. Richard Brey of Idaho State University joined participants from the student workshop. The group developed an outline of project tasks for the remainder of the fiscal year.

Individuals and groups represented at the working group meeting will generate input batch files for the following radionuclides: ^{201}Au, ^{61}Co, ^{131}Ce, ^{194}Pb, ^{183m}Os, and ^{41}Ar. Students reviewed the files during the Annual Health Physics Meeting in Tampa, FL in June 2002. Additionally, Adam Arnt of ISU wrote a DC methodology that was modified at the Health Physics Meeting student workshop. Mr. Shanahan is developing a final draft outline of the DC methodology by August 2002. An additional Working Group meeting will be held at UNLV in August or September 2002. Further modifications to this code will facilitate its use for calculating dose coefficients.

HIGHLIGHTS

- The research consortium, including Georgia Institute of Technology, Idaho State University, Texas A&M University, University of Florida, UNLV, Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), and Tbilisi State University in Tbilisi, Republic of Georgia, was established.
- A student workshop was hosted at UNLV to train graduate students from participating universities on the methodology of generating dose coefficients.
- Researchers presented the "Development of Dose Conversion Coefficients for Radionuclides Produced in Spallation Neutron Sources" at the 47th Annual Bioassay, Analytical, and Environmental Radiochemistry Conference, Las Vegas in November 2001 and at the American Nuclear Society Winter Meting, Student Mini-Conference in Reno, NV November 2001.
- "Development of Dose Conversion Coefficients for Radionuclides Produced in Spallation Neutron Sources" was presented as a poster at the Annual Meeting of the Health Physics Society, Tampa, FL June 2002.

CONTINUED PROGRESS AND FUTURE GOALS

In the second year of the project, researchers plan to expand the number of participants in the DC Working Group. Work will continue to refine and optimize the DC methodology, with a primary focus on reproducibility. The determination of internal and external dose coefficients will continue, expanding the effort to include more radioisotopes.

For FY02, the Dose Coefficient research group plans to generate DCs for approximately 86 radionuclides that could be created from spallation neutron sources. The group also plans to generate results that will be considered for inclusion in a future report from the International Commission on Radiation Protection (ICRP). It is also expected that this work will be presented and published at selected professional meetings and publications.

Research Staff
Phillip W. Patton, Principal Investigator, Assistant Professor, Department of Health Physics
Mark Rudin, Chair, Department of Health Physics

Students
John Shanahan and Yayun Song, Graduate Students

Collaborators
Keith F. Eckerman, Oak Ridge National Laboratory
Faculty and Graduate Students from Idaho State University, Georgia Institute of Technology, Texas A&M University, and University of Florida