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Data Analytics Supporting Provenance Assessment of Irradiated Nuclear Fuels

Nuclear forensics provides the ability to analyze radioactive and nuclear (RadNuc) material for the purposes of supporting the broader investigation of a nuclear security event. A comprehensive nuclear forensics capacity requires a capability to characterize and assess the provenance of materials discovered or seized from outside of regulatory control. The Government of Canada's provenance assessment capability is supported, in part, through the Canadian National Nuclear Forensics Library (NNFL) program, which is led by the Canadian Nuclear Safety Commission (CNSC). The Government of Canada's NNFL catalogues information and data about RadNuc material under Canadian regulatory control. The list of material groups captured under the Government of Canada's NNFL framework includes irradiated nuclear fuels.

Characterization of nuclear fuels through post-irradiation examination has been historically focused on collecting and interpreting data and information for the purposes of supporting reactor engineering design, performance and safety applications. Similarly, the suite of codes and analysis tools has been, with some exceptions, primarily oriented towards these same applications. This work exploits the multitude of reactor engineering-focused spent fuel data sets and modelling tools for nuclear forensic purposes. The approach uses industry standard reactor physics codes to compute the nuclide composition as a function of burnup for various nuclear fuel designs. The outputs of these models are analyzed using modern data analytics and machine learning techniques to identify highly discriminating features that allow for the determination of the source reactor design, which may also inform decision making regarding the collection and measurement of nuclides of interest for monitoring and verification applications.

This paper will present an overview of the methodology that includes the use of reactor physics codes for generating fuel nuclide composition data, the data analytic approaches taken to identify nuclides and compound features of discriminatory value, and the machine learning techniques applied to the classification of source reactor designs based on the modelled nuclide dataset. The applicability of this work is demonstrated against both open source and simulated data, and shown to be of value in supporting provenance assessment for irradiated nuclear fuel.

Gender

State

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