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#04-90 New Neutron Imaging Facility development at the Penn State Breazeale Nuclear Reactor

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Neutron imaging is a powerful tool in the field of non-destructive testing that utilizes the unique attenuation properties of neutrons to image high-density objects. The Penn State Breazeale Reactor (PSBR) at the Radiation Science and Engineering Center (RSEC) has had a neutron radiography facility for the last several decades. With the installation of a new core moderator assembly and new beam ports, a dedicated neutron beam port has become available for a new neutron imaging facility (NIF) at RSEC. The new RSEC NIF will have collimators with variable apertures and will utilize state-of-the-art equipment and software for conventional neutron radiography and tomography. The centerpiece of the RSEC facilities is the PSBR. The PSBR, which first went critical in 1955, is the nation's longest continuously operating university research reactor. The PSBR is a 1 MW, TRIGA with moveable core in a large pool and with pulsing capabilities.

Although the final design for the RSEC-NIF system is under development, it has been decided to characterize the initial Open Beam (OB) configuration for the NIF beam port by the universal standards to access the current capabilities of the facility and to set the starting point of system development. Since all current Neutron Radiography (NR) facilities around the world characterize their system capabilities using American Society for Testing and Materials (ASTM) standards dedicated to neutron imaging techniques, the same approach was taken in the categorization process of OB. Thermal neutron flux measurements with bare and cadmium covered gold foils are performed at the beginning and the exit surface at the biological side of the OB port are measured to characterize the beam. Effective collimation ratio (L/D), Beam Purity Indicator (PBI) and Sensitivity Indicator were determined for the OB in order to have an initial indication of the beam. Based on these finding we are now finalizing the aperture, filter and collimator designs.

The RSEC-NIF with an open beam and without any apertures and collimators can produce images of medium quality, being Category IV facility by ASTM designation of quality and having the effective L/D ratio between 34.6 and 42.5. However, there is plenty of room for the development of the system in improving its resolution and uniformity by the means of lead/borated aluminum collimator steps (convergent and divergent parts), a Boral primary aperture with a cadmium lining, and filters for gammas (bismuth), and fast neutrons (sapphire). In addition to that, recent flux measurement via gold foil activation in multiple places across the exit surface of the beam resulted an average thermal flux equal to 3.5×10^8 n cm^(-2) s^(-1) at 1 MW power with the fluctuation of a 6%, which indicated that the main problem in uniformity of resulting images is most likely due to direct gammas. In order to tackle the existing problems, the initial MCNP simulations are being conducted with the addition of conceptual collimator within the beam aiming the final goal of obtaining L/D ratio of more than 100, thermal neutron content of more than 65, thermal neutron flux of more than 10^6 n cm^(-2) s^(-1), and with the neutron to gamma ratio of at least 10^5 n cm^(-2) 〖mrem〗 ^(-1) at the imaging plate. These features would be sufficient to declare RSEC-NIF as Category I by the ASTM designation of quality.

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