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In-situ studies of phase transition related Pb transport in the SINQ target rods with use of the NEUTRA imaging instrument at PSI

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The key element in the SINQ target of the neutron spallation source at the Paul Scherrer Institute (PSI) is a bundle of rods fabricated from Zr-alloy tubes filled with Pb. A proton beam initiates a spallation reaction, which is accompanied with a powerful local heat release (mainly in Pb).

Despite an effective convective cooling of the rods surfaces with heavy water, the temperature of Pb in some rods may rise above the Pb melting point. Our measurements of temperatures in the SINQ targets rods bundles (in Pb and in heavy water) confirm this assumption.

Our laboratory experiments (in which the processes occurring in the rod are visualized by means of the NEUTRA imaging instrument in SINQ) show that the process of Pb melting – solidification is accompanied by migration of Pb inside the rods. Neutron images of some of the irradiated rods from dismantled rods bundles assemblies of decommissioned targets show a similar pattern.

An initial study of phenomena is performed. Both, experiments and simulations, show, that the Pb migration can create conditions leading to mechanical stressing and plastic deformation of the Zr-alloy tubes due to internal pressure from Pb. Some aspects of stress-strain state and mass transport were simulated and findings were compared with the experiments.

The paper discusses the method and results of the temperature measurements during the operation of SINQ targets; method and results of laboratory experiments aimed at studying of possible physical mechanisms of the Pb migration in the rods and of the Zr-alloy pipes stressing and plastic deformation.

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