Dynamic Strain on a Mercury Target Vessel During 800-MeV Proton Thermal Shock Tests*

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Abstract

A mercury target will be used to generate spallation neutrons from the impact of approximately 1-GeV protons in the proposed Spallation Neutron Source (SNS) facility to be built in Oak Ridge by the Department of Energy. It is proposed that short-pulse (~0.5 μs) high intensity beams of protons (~10^{14} per pulse) will bombard the target at 60 Hz. To ensure that the target vessel can withstand its thermal and mechanical loading conditions, it is important to optimize the vessel wall thickness. Sophisticated computer codes are used to model the target configuration, and a series of measurements is being undertaken to quantify the actual baseline thermal shocks that can be expected. The intense thermal shock loads are expected to cause an enormous rate of temperature rise (~10^{7} K/s), with resulting pressure waves in the mercury that may lead to large stresses on the thin walls of the mercury target. To guide the mercury target design and to benchmark the computer design codes, we are measuring transient strain on stainless steel vessels containing mercury, using fiber optic Fabry-Perot sensors.

Twenty strain sensors were attached in various axial and transverse orientations to a cylindrical stainless steel target vessel containing mercury. The vessel was 10 cm in diameter, about 15-cm long, and with a 5-cm radius hemispherical shell welded to the forward end. These sensors were used for strain measurement at the Los Alamos Neutron Science Center - Weapons Neutron Research (LANSCE-WNR) beam facility on 30-31 January, 1999. The sensors were attached with gauge lengths of about two centimeters, and were located in pairs in most areas, for redundancy and facilitation of data analysis. The 800-MeV proton deposition of 1– 3 x 10^{13} over a beam size of ~40 mm, produced peak strains of around 50 microstrains. In this paper, we will describe the experiments, including the sensors and measurement configuration, and discuss the strain data analysis.