LA-UR-97- 2433

Title: **LANSCE SHORT -PULSE SPALLATION SOURCE TARGET UPGRADE**

CONF-970503--

Author(s): J. B. Donahue, G. D. Baker, N. K. Bultman, T.O. Brun, P. D. Ferguson, R.J. Macek, M.M. Njegomir, M.A. Plum, J.E. Roberts, G. J. Russel, and W.F. Sommer

Submitted to: 1997 Particle Accelerator Conference, Vancouver, B-C

Los Alamos
NATIONAL LABORATORY

Form No. 836 R5
ST 2629 10/91

LANSCE SHORT-PULSE SPALLATION SOURCE TARGET UPGRADE

J.B. Donahue, G.D. Baker, N.K. Bultman, T.O. Brun, P.D. Ferguson, R.J. Macek, M.M. Njegomir, M.A. Plum, J.E. Roberts, G.J. Russell, and W.F. Sommer
Los Alamos National Laboratory, Los Alamos, New Mexico 87545 USA

Abstract

A project to upgrade the short-pulse spallation source target at the Los Alamos Neutron Scattering Center (LANSCE) is in progress. This upgrade will reduce the target change out time from about a year to about three weeks and permit the proton beam current to be raised to 200 μA. The project includes a new target-moderator-reflector system, a new suite of moderators for four new flight paths, improved auxiliary systems, remote handling capability, and a new crane and service building. The project has also supported calculations and experiments for target neutronics, rod-target thermo-hydraulics, and corrosion-related measurements in a proton beam. The final engineering design is now complete and the project has begun fabrication and procurement. Installation will begin in the fall of this year.

1 INTRODUCTION

The short-pulse spallation target is located at the Manuel Lujan, Jr. Neutron Scattering Center (MLNSC) at the Los Alamos Neutron Scattering Center (LANSCE). The present target is a split (flux-trap) solid cylinder made from a tungsten alloy. [1] The target feeds a liquid hydrogen moderator, a high-resolution water moderator, and two high-intensity water moderators. Each moderator is viewed by three neutron flight paths and their associated instruments. The proton beam is supplied from a storage ring (PSR) which stores 800-MeV protons from the linear accelerator and delivers 250ns-wide pulses at 20Hz. The average current is presently limited to 70μA due to stress limitations in the solid upper target.

The target upgrade is part of a larger project, the LANSCE Reliability Improvement Project, which has the goal of improving the overall availability and productivity of the facility. [2] The goals of the target upgrade are

- Change out of the target-moderator-reflector system (TMRS) insert in three weeks or less
- Provide coupled upper-tier moderators to service four new flight paths
- Increase current capability from the present 70μA (56kW) to 200μA (160kW)
- Preserve the neutronic performance of the existing lower-tier flight paths

When the new target is installed and commissioned in May 1998, we will be able to raise the beam current to over 100μA. The recently-approved SPSS enhancement project, when complete, will allow us to raise the current to 200μA at a repetition rate of 30Hz.

2 SIMULATIONS AND TESTING

The target design process has been guided by extensive computer simulations and engineering tests. We have also benefitted from the APT materials irradiation experiments led by one of us (WFS).

The final design choices were a compromise between neutronic performance, operational reliability, good engineering practice, radioactive materials handling, and waste management considerations.

2.1 TMRS neutronics

The neutronic performance of the TMRS was calculated using the LAHET Code System. [3] These simulations were used to determine the moderator thickness, target material, target thickness, reflector material, reflector thickness, and the choice of coolant. Studies were done for various partial decoupling schemes in the upper tier of moderators and several choices of decoupling materials. The moderator overlap and the flux trap gap were also varied in the simulations. [4,5]

2.2 Target thermo-hydraulics

The LAHET calculations also provided the source term for beam heating in the target. The computational fluid dynamics code FLOW-3D [6] was then used to model the water cooling.

The clad rod bundle target concept was also tested experimentally since it has not been used before in spallation targets. This design was conceived to control the problem of activated corrosion and erosion products contaminating the cooling system and making maintenance operations difficult and possibly limiting the lifetime of the target. The rod bundle target consists of 11.1mm diameter tungsten rods inside 0.25mm-thick Inconel tubes.

The test program consisted of placing the Inconel tubes in a water cooling loop and heating them electrically to simulate the peak heat flux in the target of 142 watts/cm^2. Pitch-to-diameter ratios (p/d) of 1.02, 1.05 and 1.10 were tested. A failed test at p/d=1.05 led us to consider a plate target as an alternative. After a careful analysis and repeat experiments, we determined that the rod bundle concept will work and has a sufficient thermal margin at 200μA.

2.3 Corrosion measurements in a proton beam

The upgrade project has contributed to the materials irradiation program. Various material samples, including clad and unclad tungsten rod bundles, have been irradiated with a one-milliamp beam of 800-MeV protons. We now have experience with operations and maintenance on tungsten systems and we will soon have measurements of the bulk properties of irradiated materials.

The results from this work are very preliminary but we have been able to make some general observations. After about two amp-hours of operation, corrosion and erosion of tungsten was evident but there were no catastrophic failures. The material still had some strength. The auxiliary water systems were difficult to maintain for unclad tungsten because of activated corrosion products which tended to deposit on fittings and flex lines.

3 HARDWARE DESIGN DESCRIPTION

In order to meet the goal of a three-week replacement schedule, the targets, moderators, and inner reflector are mounted on a single (TMRS) insert. The project will build two inserts, compatible crypt shielding, the outer reflector and a new crane and access building. It will also provide tooling fixtures for assembling future targets and facilities for handling irradiated targets. The target insert is shown in Figure 1.

3.1 Target

The target team has carried two different concepts for the upper target to final design. This is because of concerns with the thermo-hydraulics of rod bundles and the corrosion of bare tungsten. The baseline design is a plate target with seven pure tungsten plates and no cladding. The fall-back design is an Inconel-clad tungsten rod bundle with a pitch-to-diameter ratio of 1.05. The rest of the target insert is designed to be compatible with either choice.

The plate target is preferred for neutronic performance and is simpler to build than a rod bundle. However, the plate target is suceptible to corrosion and the design depends upon the bulk properties of tungsten, such as thermal conductivity and strength. Some of these properties will change with irradiation.

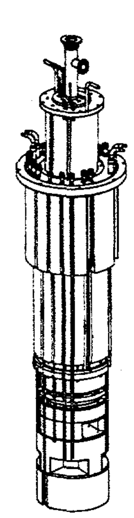

Figure: 1 The TMRS insert. The proton beam enters vertically through the pipe at the top. The openings for the neutron flight paths can be seen near the bottom.

The lower target is not as severly stressed with only 10% of the bulk heating rate as the upper target. It is made from a solid piece of tungsten.

3.2 Moderators

The lower-tier moderators are in flux-trap geometry and fully decoupled. They are designed to give the same performance as the existing flux-trap moderators. The upper-tier moderators are in backscattered geometry and are partially coupled. Table 1 lists the moderator types and the flight paths that they serve.

Table 1 Moderator types and their associated flight paths.

FP #	Moderator Type	Coupling
1,2,16	high-resolution water	decoupled
3,4,5	high-intensity water	decoupled
6,7,8	high-intensity water	decoupled
9,10,11	liquid hydrogen	decoupled
14,15	water	coupled
12,13	liquid hydrogen	coupled

3.3 Reflectors

The inner reflector is edge-cooled solid beryllium. Since there is no water in the beryllium to capture neutrons, neutronic performance is enhanced and light water can be used for a coolant. The beryllium reflector is 0.25m thick and is attached to the removable TMRS insert.

The outer reflector is lead with embedded stainless steel cooling lines. It has an inner diameter of 0.60m and an outer diameter of 1.14m. It is part of the crypt shielding but it can be removed through the roof using the bridge crane if necessary.

3.4 *Materials handling*

Safe and efficient methods for handling irradiated components is essential in order to meet the goals of the upgrade. We have the benefit of over twenty years experience with high-power (one-megawatt) beams and we have developed a substantial remote handling capability.

The target insert is removed and replaced through a special access port in the roof of the target cell. Irradiated targets are pulled directly into a transfer cask using a radio-controlled bridge crane. The transfer cask shields personnel from radiation and controls contamination. Secondary containment is provided by a building over the access port.

Irradiated targets will be taken to the facilities in the high-power beam area for post-mortem testing. We have the option of storing them in special culverts for future use or cutting them up for disposal. There is a new hot cell facility at the CMR building for detailed analysis of irradiated samples. The MONITOR remote handling system will be used for operations in Area A.

4 ACKNOWLEDGEMENTS

The work was supported by the US DoE and DoD. The target team is grateful to Guenter Bauer and Tim Broome for stimulating conversations and good advice.

REFERENCES

[1] G.J. Russell, C.D. Bowman, E.R. Whitaker, H. Robinson, and M.M. Meier, 'LANSCE High-Power Target-Moderator-Reflector-Shield,' ICANS-VIII (November 1985).

[2] R.J. Macek, *et al.*, 'Overview of Progress on the Improvement Projects for the LANSCE Accelerator and Target Facilities', these proceedings.

[3] Richard E. Prael and Henry Lichtenstein, 'User Guide to LCS: The LAHET Code System,' Los Alamos National Laboratory Report LA-UR-89-3014, http://www-xdiv.lanl.gov/XTM/lcs/lahet-doc.html (September 1989).

[4] G.J. Russell, P.D. Ferguson, E.J. Pitcher, and J.D. Court, 'Split-Target Neutronics and the MLNSC Spallation Target System', ICANS-XIII, October 11-14, 1995.

[5] P.D. Ferguson, G.J. Russell, and E.J. Pitcher, 'Reference Moderator Calculated Performance for the LANSCE Upgrade Project,' ICANS-XIII, (November 1995)

[6] FLOW-3D Computer Code, Version 7.0, Flow Science Inc., 1325 Trinity Dr., Los Alamos, NM 87544, 1996.