✓
UCRL-81860-1979
MASTER

PREPRINT UCRL- 81860

Lawrence Livermore Laboratory

RTNS-II NEUTRON SOURCES: STATUS REPORT

J. C. Davis, D. W. Heikkinen, J. L. Held, C. M. Logan and J. E. Osher

March 1979

This paper was prepared for submission to the
IEEE Particle Accelerator Conference, March 12-14, 1979
Sheraton Palace Hotel, San Francisco, California

This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint is made available with the understanding that it will not be cited or reproduced without the permission of the author.

RTNS-II NEUTRON SOURCES: STATUS REPORT

J. C. Davis, D. W. Heikkinen, J. L. Held,
C. M. Logan and J. E. Osher

University of California, Lawrence Livermore Laboratory
Livermore, California 94550

INTRODUCTION

The Lawrence Livermore Laboratory has recently completed construction of a 14 MeV neutron irradiation facility for materials research in support of the fusion energy program. This facility, called the Rotating Target Neutron Source-II (RTNS-II) facility, contains two independent neutron sources, each consisting of an air-insulated 400 kV deuterium accelerator and a tritium target assembly which rotates at 5000 rpm. The accelerators are designed to deliver a 150 mA, 400 keV D^+ beam to a 1 cm spot on the titanium-tritide target. Neutron source strength produced at this current is 4×10^{13} n/s; irradiation samples may be placed within 3 mm of the beam spot where the flux is 1×10^{13} n/cm²s.

During the course of the construction project, one accelerator was assembled temporarily in an unshielded enclosure for tests with H^+ and H_2^+ beams. Based upon the results of those tests, some modifications in design were made and incorporated in both accelerators when installed in the new building. This paper discusses the experience with both the prototype accelerator and the first accelerator operated as a neutron source. Other portions of the project, e.g. target system, tritium systems, etc. are described in detail elsewhere¹.

ACCELERATOR DESIGN

Details of the deuterium accelerator design have been given previously.^{1,2} Briefly, the high voltage terminal contains a multi-aperture duopigatron ion source followed by a 90° double-focussing magnet to separate the D^+ component from molecular species produced by the ion source. A solenoid lens following the separation magnet is used to match the D^+ beam into a low gradient (15 kV/cm) acceleration column. Two 10 cm aperture quadrupole triplet lenses and a single steering magnet are used to transport the beam to the target position approximately 4 m from the accelerator.

Design of the transport system assumed complete space charge neutralization of the beam in the low energy and high energy drift spaces. The quadrupole triplet field strengths are adequate to compensate for up to 50% residual charge on the beam. Normalized emittance assumed in the transport calculations was 2.5 mm-mrad.; measured emittance for the multi-aperture source used has been as low as 1 mm-mrad.

PROTOTYPE ACCELERATOR

Contracting authorization for the RTNS-II project was given in May 1976. In the spring of 1977 the 400 kV, 300 mA high voltage supplies, high voltage terminals, and 75 kVA, 400 kV isolation transformers passed acceptance tests at Emile Heafely, Ltd. in Basel and were shipped to Livermore. By July 1977, one complete accelerator was under assembly in a temporary enclosure at LL for prototype tests. In December 1977 the high voltage terminal was hipotted to 400 kV and H^+ and H_2^+ beams of over 150 mA at 15-20 keV were delivered to a diagnostic tank installed at the position of the acceleration column. The acceleration column was then installed and the accelerator completed as designed to the first quadrupole triplet

in the beam transport system. The diagnostic tank was mounted in the drift space following the triplet.

Operation with hydrogen beams began in January 1978. Maximum H_2^+ current and energy obtained were 40 mA at 250 keV. Above 10 mA it was necessary to replace the stationary beam dump with a rotating target as the beam spot could be focussed to diameters less than 1 cm. The maximum current and energy were limited by bremsstrahlung radiation outside the unshielded electrostatic enclosure containing the accelerator. Fields up to 300 mrem/hr were measured at a location 3 m from the acceleration column at 90° to the beam line. Field mapping done by attaching thermoluminescent dosimeters to the acceleration column and various terminal components produced distributions consistent with electron flow up the acceleration column. Several graphite liners were placed inside the transport system in the high voltage terminal without reducing these fields. Variation of the bremsstrahlung fields with current, voltage, and pressure in the transport system suggested that the most likely source of electrons was ionization of gas within the acceleration column itself; pressure at the ground end of the column rose from 6×10^{-7} Torr with beam on.

It was decided to attempt to reduce this problem in the final accelerator design by further decoupling the source and acceleration column. The ion source stand containing source, bending magnet, solenoid lens and 2000 l/s turbopump was moved 45 cm back from its original location. This change made possible installation of a 1500 l/s turbopump, a beam viewer, a beam stop for current measurement and a variable aperture collimator. Prototype accelerator operations were terminated in March 1978 and relocation to the new building begun.

FIRST NEUTRON SOURCE

In March 1978 the building housing the RTNS-II sources was completed and became available to the project for installation of the accelerators. The first accelerator to be installed was the second of the two systems; the prototype was relocated as the second accelerator in the new building. All modifications suggested by prototype operation were incorporated in both machines. A view of the high voltage terminal and Cockcroft-Walton power supply is shown in Figure 1. The beam transport system and target assembly in the separate target cell are shown in Figure 2.

Initial acceleration of a beam by the first accelerator was accomplished in August 1978. By November 1978 the facility tritium and closed loop water systems were complete allowing operation on a tritium loaded target. In the first run on a tritium target 1.2×10^{13} n/s were produced with a 50 mA D^+ beam at 330 keV. Neutron source strength was measured with a tissue equivalent ion chamber previously calibrated at the RTNS-I neutron source.³ To measure the size of the beam spot on target, thin Cu foils were placed 2 mm from the rotating target and activated by 14-MeV neutrons. These foils were then used to expose photographic film, allowing the profile of the neutron-emitting region to be measured by photodensitometer tracing of the negative. For irradiation times of 30 minutes, the average beam spot size inferred from this technique

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

"Work performed under the auspices of the
U.S. Department of Energy by the Lawrence
Livermore Laboratory under contract number
W-7405-ENG-48."

R29

1. The machine is a large, complex piece of industrial equipment, possibly a pump or engine, with various pipes, valves, and a large flywheel visible. The image is grainy and appears to be a photocopy or a scan of a printed document.

2. The machine is a large, complex piece of industrial equipment, possibly a pump or engine, with various pipes, valves, and a large flywheel visible. The image is grainy and appears to be a photocopy or a scan of a printed document.

3. The machine is a large, complex piece of industrial equipment, possibly a pump or engine, with various pipes, valves, and a large flywheel visible. The image is grainy and appears to be a photocopy or a scan of a printed document.

4. The machine is a large, complex piece of industrial equipment, possibly a pump or engine, with various pipes, valves, and a large flywheel visible. The image is grainy and appears to be a photocopy or a scan of a printed document.