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The RTNS-II Fusion Materials Irradiation Facility

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ABSTRACT

The Rotating Target Neutron Source (RTNS-II) facility provides an intense source of 14-MeV neutrons for the fusion energy programs of Japan and the United States. Each of the two identical accelerator-based neutron sources is capable of providing source strengths in excess of 3×10^{13} n/s using deuteron beam currents up to 150 mA.

At the present time, the facility operates a minimum total of twenty shifts (8-hour) per week using both neutron sources. Because of funding cut-backs, future operations will be limited to one neutron source. The possibility exists to increase neutron output by combining the high voltage power supplies, thereby increasing the current capability of the operating neutron source. This would allow approximately a factor of three increase in neutron output. Using existing equipment, an ion source test stand has been constructed to improve ion source output. Conceptual design studies have been made concerning a factor of ten increase in neutron output. Detailed studies of needed target improvements have been made and will be discussed.

The present status of the facility, as well as the various upgrade options, will be described in detail.

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Due to the large number of systems which need modification, the factor of ten upgrade would take approximately three to four years during which time one RTNS-II neutron source would be left unmodified and operational with only short interruptions.

V. Summary

We have briefly outlined the present status of the RTNS-II facility and two possible upgrades. The upgrades would provide a factor of three to ten more fusion neutrons. Either option has a high degree for success and differ only in cost and time. However, present funding trends are not optimistic for upgrade or indeed the future of the facility.

References

[1] Recent Progress at RTNS-II, D. W. Heikkinen and C. M. Logan, Nucl. Inst. and Methods, B10/11, 835 (1985).

[2] Ion Source Development at RTNS-II, D. Massoletti and D. W. Heikkinen, Nucl. Inst. and Methods, B10/11, 779 (1985).

[3] Fusion Materials Science at Reactor 14-MeV Neutron Fluxes: Upgrading RTNS Targets into the Multi-Megawatt/M^2 Regime, David B. Tuckerman, UCID-20040, (1984).

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I. Introduction

The Rotating Target Neutron Source Facility (RTNS-II) at Lawrence Livermore National Laboratory has been in operation since 1979. The purpose of the facility is to provide an intense source of 14-MeV neutrons for irradiation of materials of interest to the fusion materials program. Since 1982 the facility has been jointly supported and utilized by the Japanese and U.S. fusion programs through the Ministry of Education, Culture and Science (Monbusho) and the DOE Office of Fusion Energy, respectively.

The RTNS-II Facility contains two identical accelerator-based neutron souces which use the D-T reaction to generate neutrons. Operations at the facility at present consist of at least twenty eight-hour shifts per five-day week. In fact, both neutron sources operate frequently on a twenty-four-hour, five-day week. Budgetary considerations will soon reduce operation to one neutron source, however.

Irradiations have been done on a wide variety of materials over the past years. Some irradiation packages have contained several thousand samples. Sample temperatures have ranged from 20^{o} K to 720^{o} K during irradiation. Among samples irradiated have been metals, alloys, ceramics, superconductors, various diagnostic equipment and targets for nuclear cross section measurements. Fluence requirements are generally in the range of 10^{16} to 10^{19} n/cm^2. Irradiations presently are scheduled through March of 1987.

II. Present RTNS-II Characteristics

When the irradiation schedule began in early 1979 using only one neutron source, nominal neutron production was approximately 10^{13} n/s using about 45 mA of beam. Even though the facility operates in a production mode, various developments and improvements have been made which have increased neutron production. These improvements have been described in detail elsewhere [1]. Refer to reference 1 for a more complete description of the neutron sources (see Fig. 1). Operation of the second neutron source began after Japan joined in the support and utilization of the RTNS-II project.

Table I shows the nominal present and initial operating characteristics of the RTNS-II neutron sources. It should be noted that both neutron sources have essentially the same characteristics.

A comparison of total neutron production at RTNS-II in calendar year 1985 versus 1980 shows an increase of approximately a factor of five even though in 1985 approximately two months of one neutron source were not available due to vacuum system modification. A comparison of one neutron source operation for ten months in 1985 versus twelve months in 1980 shows an increase in neutron production of a factor of three. It should be noted that these improvements were achieved while maintaining a full irradiation schedule.

To increase neutron production further, consideration has been given to possible upgrades of the RTNS-II neutron sources. Two possible upgrades have been considered. These are the "factor of three" and "factor of ten" versions. These will be described in the following sections.

III. Factor of Three Upgrade

In this section we discuss an upgrade of a RTNS-II neutron source which would provide a factor of three increase in neutron source strength. This upgrade would require no major revisions in the facility or to the neutron source. It could also be accomplished with a minimum disruption of the irradiation schedule.

In the following table we will discuss the various major subsystems and components of a neutron source indicating what needed changes are required for a factor of three upgrade.

As can be seen from Table II, the number of components which would require change in a "factor of three" upgrade are small in number. The major items are conversion of the 400 kV, 300 mA power supply to 500 mA capability and further improvement in the ion source. The upgrade of the power supply is very straightforward and can be accomplished in one of two ways, by combining the required parts from the existing two power supplies or by purchasing needed equipment from the company that manufactured the original equipment. Certainly, the purchase of the necessary equipment would allow the facility to retain the flexibility of retaining both neutron sources in operational condition.

The improvements required for increased ion source output will be facilitated by an Ion Source Test Stand which has been constructed at RTNS-II using spare parts inventory. Previous ion source work was only able to be done when a neutron source was not scheduled for an irradiation. The availability of a test stand will allow a more direct effort on ion source improvements. Ion source work done previously has been described elsewhere [2].

IV. Factor of Ten Upgrade

The factor of three upgrade described above is a relatively inexpensive and straight-forward modification of a present RTNS-II neutron source. However, there is an obvious need for even higher neutron fluxes in order to test fusion device components to higher fluences. Therefore conceptual design work has been done on a factor of ten upgrade to the RTNS-II facility. As might be expected, a factor of ten improvement requires upgrading or replacement of most sub-components in the system. The shielding and the tritium scrubber system are considered adequate as is the neutron yield diagnostic system (refer to Table II).

The system which is of most concern in a factor of ten upgrade is the rotating target system. However, detailed studies [3] have indicated that modifications to the target system could lead to a factor of ten improvement. Among these are:

- optimized cooling channel profile
- cladding of the TiT_x to retain tritium
- thinner TiT_x layer with Pd underlayer to remove deuterium
- optomized beam voltage

Other more complicated modifications such as corrugation of the targets would lead to further improvement. All needed target improvements can be tested on scale sizes using the RTNS-I facility. This would give confidence the targets were performing as expected.

Table I

Initial and Present Characteristics of RTNS-II Neutron Sources

	Initial	Present
Total energy of beam	360 kev	365 keV
Ion source extraction voltage	25 kV	35 kV
Ion source arc current	40 A	50 A
Maximum beam current	45 mA	150 mA
Maximum neutron production	10^{13} n/s	3.5×10^{13} n/s
Target substrate size	23 cm	50 cm
Target tritium content	4.4×10^{7} MBq	1.8×10^{8} MBq

Table II

Subsystem Changes Needed for X3 Upgrade

Subsystem	Change/Implement	Comment
<u>High Voltage Equipment</u>		
1. 400 kV supply	yes	Combine present two supplies or purchase. Straightforward.
2. HV terminal	no	
3. Isolation transformer	no	
<u>Ion Source Systems</u>		
1. Ion source	yes	Test stand available for ion source work
2. Vacuum system	no	
3. Magnet and optics	no	
4. Control system	no	
5. Power supplies	maybe	As needed but straightforward
6. Acceleration column	yes	Parts for redesigned column on hand
<u>Beam Transport System</u>		
1. Vacuum system	no	
2. Optics	no	
3. Controls	no	
<u>Diagnostics</u>		
1. Neutron yield	no	
2. Beam spot	yes	Improved position and size disgnostics
3. Target temperature	yes	Desirable to implement
4. Residual gas analysis	yes	Desirable to implement
<u>Rotating Target System</u>		
1. Rotating seal	no	
2. Substrate	no	
3. TiT_2 layer	no	
4. Target chilled water cooling	maybe	May need upgrade
5. Controls	no	
<u>Central Control System</u>		
1. Operator interface	no	
2. Data presentation	maybe	Primarily software
3. Data logging	maybe	Primarily software
<u>Radiological Systems</u>		
1. Shielding	no	
2. Tritium scrubber	no	
3. Remote handling system	yes	Implement remote/semi-remote system

RTNS II NEUTRON SOURCE SCHEMATIC

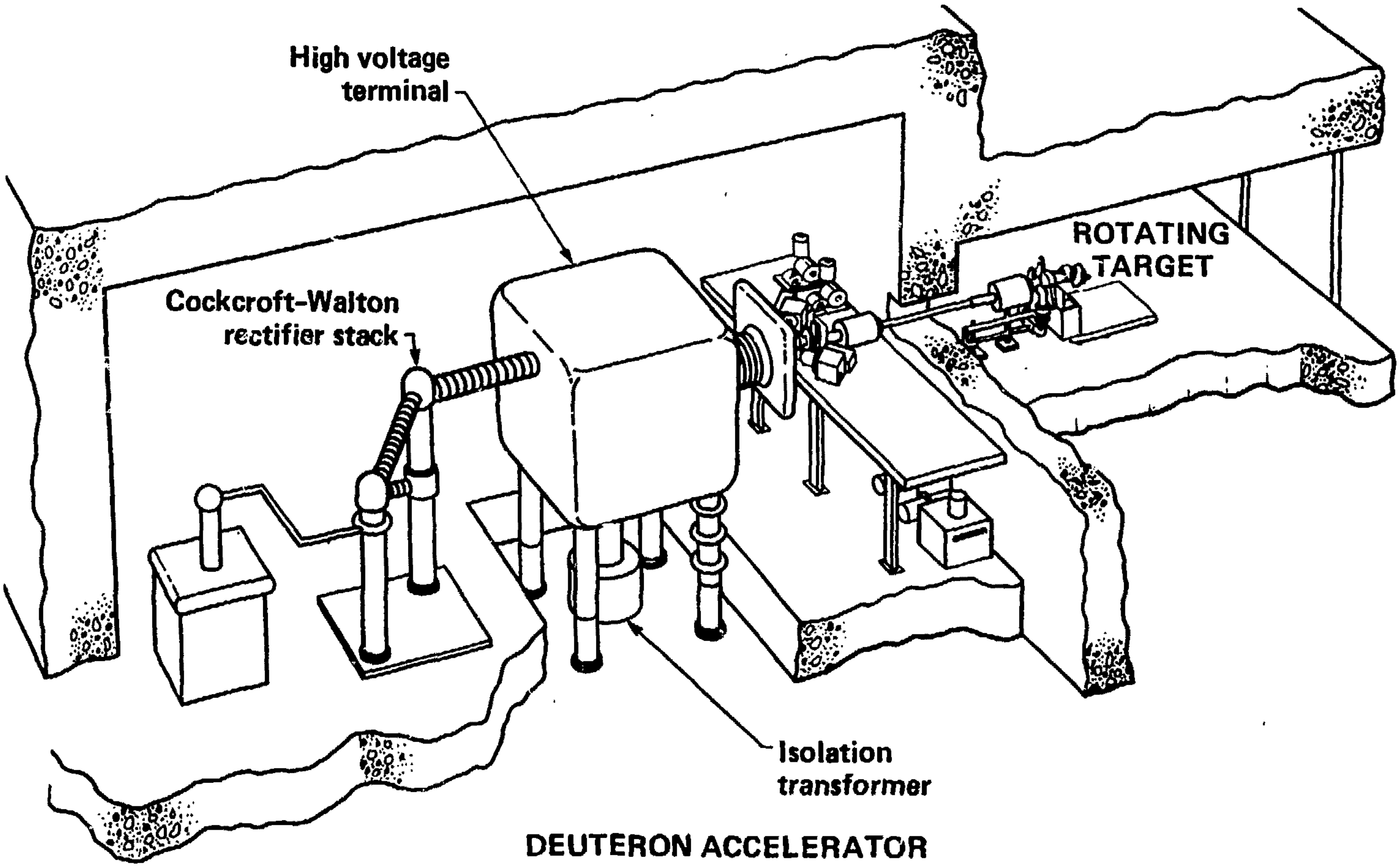

Fig. 1. A schematic diagram of a RTNS-II neutron source. The X3 modification would require addition of another step-up transformer and Cockroft-Walton section.