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THE OPERATION OF THE TOKAMAK FUSION TEST REACTOR TRITIUM FACILITY

Charles A. Gentile
Princeton Plasma Physics Laboratory
P.O. Box 451
Princeton, New Jersey 08543, USA
(609)243-2139

James L. Anderson
Los Alamos National Laboratory
Mail Stop H-811
P.O. Box 1663
Los Alamos, New Mexico 87545, USA
(505)667-0288

Paul H. LaMarche
Princeton Plasma Physics Laboratory
P.O. Box 451
Princeton, New Jersey 08543, USA
(609)243-3244

ABSTRACT

The TFTR tritium operations staff has successfully received, stored, handled, and processed over five hundred thousand curies of tritium for the purpose of supporting D-T (Deuterium-Tritium) operations at TFTR. Tritium operations personnel nominally provide continuous round the clock coverage (24 hours/day, 7 days/week) in shift complements consisting of 1 supervisor and 3 operators. Tritium Shift Supervisors and operators are required to have 5 years of operational experience in either the nuclear or chemical industry and to become certified for their positions. The certification program provides formal instruction, as well as on the job training. The certification process requires 4 to 6 months to complete, which includes an oral board lasting up to 4 hours at which time the candidate is tested on their knowledge of Tritium Technology and TFTR Tritium systems. Once an operator is certified, the training process continues with scheduled training weeks occurring once every 5 weeks. During D-T operations at TFTR the operators must evacuate the tritium area due to direct radiation from TFTR D-T pulses. During this time operators maintain cognizance over tritium systems via a real time TV camera system. Operators are able to gain access to the Tritium area between TFTR D-T pulses, but have been excluded from the tritium area during D-T pulsing for periods up to 30 minutes. Tritium operators are responsible for delivering tritium gas to TFTR as well as processing plasma exhaust gases which lead to the deposition of tritium oxide on disposable molecular sieve beds (DMSB). Once a DMSB is loaded, the operations staff remove the expended DMSB, and replace it with a new DMSB container. The TFTR tritium system is operated via detailed procedures which require operator sign off for system manipulation. There are >300 procedures controlling the operation of the tritium systems. In addition detailed procedures are employed to maintain configuration control over the tritium facility. All maintenance activities in the tritium area are controlled via a work permit system which requires that the Tritium Shift Supervisor sign the permit and be cognizant of work in the area. All manipulation of tritium systems during maintenance activities are performed under the direct supervision of the Tritium Shift Supervisor.

I. INTRODUCTION

The TFTR tritium facility has been in full operation for approximately two years and has matured into a dependable system for the delivery of tritium to the Tokamak Fusion Test Reactor (TFTR). A staff of 20 certified tritium operators which include 5 shift supervisors and 15 operators maintain continuous round the clock coverage (24 hours per day, 7 days per week) in shift complements of 1 supervisor and 3 operators. The PPPL tritium operator certification process requires approximately 4 to 6 months to complete and is brought to closure when the candidate successfully completes a comprehensive oral board addressing the operation of the TFTR tritium systems. The typical technical background of a TFTR tritium operator includes experience in the U.S. Navy Nuclear Propulsion Program and in some cases a technical college degree. The current shift rotation schedule has operators on a 5 week rotation. This schedule includes (in a 35 day period) 14 twelve hour shifts, 5 eight hour shifts (when training is performed), and 16 days off. In addition to operating the physical plant, operators are responsible for developing maintenance, repair, and operations procedures in concert with cognizant engineers.

II. OPERATIONS

A strong commitment to safety is the corner stone of all operations performed at TFTR. The daily plan of the day (POD) meeting with the operations staff continually emphasize the need to work in a safe, *efficient fashion. During the POD daily tasks* are scheduled to ensure that activities are compatible with *the configuration of the facility.* In addition, tasks associated with supporting TFTR D-T operations are assigned priority in order to ensure the success of the D-T run.

Operators on duty supporting D-T experiments, under the direction of the TFTR Shift Supervisor, heat up the tritium storage and delivery system uranium-bed to 400°C in a highly proceduralized process and typically pressurize the tritium gas delivery manifold with up to 2000 torr of tritium. There are 3 uranium-beds in the TSDS, each capable of holding 50,000 curies of tritium. Due to site inventory limitations, the single bed loading capacity is limited to 25,000 Ci. A site limit of 50,000 Ci of tritium in process is enforced, which complies with final safety analysis report design criteria, and technical specification requirements. Tritium is typically injected into the TFTR vacuum vessel via neutral beam injection. During D-T operations at TFTR, tritium operators exit the tritium facility due to direct radiation (neutron radiation) created from the TFTR D-T pulse. During these times, tritium operators maintain cognizance over the tritium facility with a real time TV camera system which provides the operators with a view of the tritium control console. Employment of TV cameras in the TFTR Control Room also provide real time monitoring of the tritium facility. Between D-T pulses, operators are able to gain access back to the tritium facility providing them with time to perform surveillance functions. Tritium operators have been excluded from the area for up to 30 minutes in full D-T operations with no loss of system performance.

Daily, at the conclusion of D-T operations, plasma exhaust gases which are trapped on cryogenic panels are collected through neutral beam regeneration, and are sent to one of two 7.2 m^3 tritium gas holding tanks. The tritium gas in these tanks is processed by the torus cleanup system in a manner which leads to the deposition of tritium oxide onto cartridge type disposable molecular sieve beds (DMSB). There are two types of DMSB cartridges at TFTR. The first, Type A container, is a stainless steel container (resembling a beer keg) which is designed to hold ≈8 lbs of water and <1000 Ci of tritium. The other, Type B container, is an elongated cylindrical stainless steel container designed to hold ≈7 lbs of water and up to 25,000 Ci of tritium. In two years of operations, the facility has used approximately 6 Type A containers and 34 Type B containers. Type A containers are typically sent to the Hanford facility for long term storage, while the Type B containers are sent to Westinghouse Savannah River Station for tritium recovery.

A Tritium Purification System (TPS) employing cryogenic distillation is currently being commissioned at PPPL. The TPS will provide TFTR the ability to recycle tritium not used in the TFTR vacuum vessel during D-T operations. TPS influent will originate from a plasma exhaust tank (PET). The PET will collect effluent gases from the TFTR vacuum vessel, and will reclaim tritium which will be sent back to the Tritium Storage and Delivery System for storage on the uranium-beds.

As of May 1995, TFTR tritium systems have processed >500,000 curies of tritium with up to 20,000 curies being processed in a single D-T run week.

The TFTR tritium facility is operated with >300 detailed procedures that control specific operations and configuration control. A "run copy" of the controlled procedure is signed out of the TFTR operations center where it is logged "in use" and employed to perform a specific task. After the procedure is completed, the document is reviewed by the tritium operations management, and is returned to the operations center where it is logged and archived.

Maintenance and repair activities are also performed with detailed documents including a task specific procedure and a work permit which must be approved by the Tritium Shift Supervisor prior to commencing the task. All tasks in the tritium area are controlled by the Tritium Shift Supervisor who is responsible for ensuring (in real time) that tasks performed are compatible with tritium operations, and performed in a safe manner. Compatibility of tasks and plant configuration are critical to the efficient operation of the tritium facility.

TFTR D-T operating parameters are proceduralized and defined (TFTR procedure OP-AD-77) detailing various mode configurations for TFTR. Three distinct operating modes are defined: Mode 2 in which TFTR is in full D-T operations, Mode 1 by which tritium can be moved throughout the facility with no D-T operations, and Mode 0 which includes a cold shutdown of the tritium plant with no tritium movement on the site.

Typically when not performing D-T pulses at TFTR, the facility is configured for Mode 1 operations, which also supports radiological maintenance activities.

III. CONCLUSION

The TFTR tritium facility has processed over 500,000 curies of tritium in a safe, efficient manner. The employment of well trained certified tritium operators, detailed procedures, good communications, and proactive management oversight have led to the maturing and efficient operation of TFTR tritium systems. The successful and safe operation of the tritium facility has supported TFTR in producing 10.7

million watts of fusion power and world record temperatures.

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